Earthquakes, tsunamis and landslides in the Corinth rift, Greece.

A multidisciplinary approach for measuring, modelling and predicting their triggering modes and their effects.

3HAZ-CORINTH

9 October 2003

Specific Targeted Research Project

Institut de Physique du Globe de Paris (IPGP) France
Ecole Normale Supérieur de Paris (ENS), France
CNRS/GeoAzur, France
Institut Français du Pétrole (IFP), France
Institut de Radioprotection et de Sûreté Nucléaire, (IRSN) France
University of Paris 6 (UP6), France
University of Patras (UPATRAS), Greece
National University of Athens (NKUA), Greece
Hellenic Center for Marine Research (HCMR), Greece
National Observatory of Athens (NOA), Greece
University of Thessaloniki (AUTH), Greece
Istituto Nazionale di Geofisica e Vulcanolgia (INGV) , Italy
Università di Bologna (DFUNIBO), Italy
World Agency of Planetary Monitoring and Earthquake Risk Assessment (WAPMERR), Switzerland
National University of Ireland, Dublin (NUID/UCD),
Charles University Prague (CUP), Czech Republic
NEURON, SA, Greece
Observatoire de Physique du Globe de Clermont-Ferrand (OPGC), France

Coordinator:
Pascal Bernard
Institut de Physique du Globe de Paris (IPGP)
bernard@ipgp.jussieu .fr

CONTENT:

- Table 1: CRL resources

B4.3 Mobilization of critical mass

- Table 2: STREP man-month effort

B4.4 Adequation of financial plan

- Budget balance
- Global level of requested funding from EC
- General balance between countries
- General balance between hazards
- Optimization
- Table 3 : Requested grant from E.C per Work-Package and Partner
- Table 4: Requested grant from E.C per financial post

B4.5 Main subcontraction

1. Observatoire Midi-Pyrénées (OMP)
2. Geosciences Rennes UMR 6118
3. National Technical University of Athens (NTUA)
4. Carnegie Institution of Washington
5. EDAFOMICHANIKI, geotechnical company, Athens
6. Drilling companies, not yet identified
7. Hydrogeological studies

B.5 Project management

B.5.1 Steering committee

B5.2 Meetings

B5.3 Communication between and within work packages

- Logistic:
- Scientific:
- Internal reports:

B5.4 Conflicts

B5.5 Communication with the Commission

B5.6 Coordination with the Corinth Rift Laboratory management structure

B5.7 Management of intellectual properties:

- Data
- Technological innovation

B6 Workplan

B.6.a. Research, Technological development/innovation

- WP1: Seismicity Monitoring and Modeling
- WP2: Long term tectonic deformation
- WP3: Short term tectonic deformation
- WP4: Aseismic transients and precursors
- WP5: Landslides
- WP6: Offshore slope failure and tsunamis
- WP7: Sensor-innovation and demonstration
- WP8: CRL information systems: Alarms, Webpage and Data-Base

B6.b. Demonstration activities

- WP7: Sensor-innovation and demonstration

B6.c. Project management activities/ assessment of progress& results

- Graphical representation of WP interdependence
- Management through the CRLWEB net

- Main risk related to the WPs
- Work package list
- Deliverable list
- WP forms

B.7 Other issues

- Potential ethical issues
- EC-policy related issue:

Earthquakes, landslides and tsunamis in the Corinth rift, Greece.

A multidisciplinary approach for measuring, modelling and predicting their triggering modes and their effects.

3HAZ-CORINTH

Abstract

The project will contribute to better measure, model, and predict the processes leading to earthquakes, landslides, submarine slides, and tsunamis, and their effect in terms of hazard. The target area is the rift of Corinth, well known for its exceptional activity with respect to these hazards. This work will focus on the western end of the rift, close to the cities of Patras and Aigion, where the risk is highest.

We will study the short term seismic hazard with methods involving seismology, geodesy, geophysics, and geochemistry. In addition to strong motion analysis and prediction, transient processes (seismic swarms, "silent" earthquakes, fluid transients) will be studied, for a better modelling fault mechanics and earthquake preparation processes. In addition to the existing monitoring arrays and data base, specific new instrumentation will be built. Near-real time alarms systems for significant earthquakes will be developed and tested. For the long term seismic hazard, the seismic potential of active faults will be assessed on land and offshore.

For submarine slope failures, places of past and future potential slumps will be mapped, and complemented by marine sediment coring and dating on selected places. Scenarios of slope failure and of coseismic displacement of the sea floor will be the inputs for tsunami modelling. The latter will be implemented using the existing high resolution bathymetry for modelling of the wave run up. Early warning alarms will be developed and tested.

For landslides, the main objective is to monitor and model the perturbation of the sliding of a well documented active landslide, in response to ground shaking from local earthquakes. Continuous GPS, seismic and tilt monitoring, and repeated advanced geodesy, will quantify sliding rates and constrain first order models. The feasibility of alarm systems will be studied.

B.1 Scientific and technological objectives of the project and state of the art

B1.1 The Corinth rift: a multi-risk, natural observatory

The main objective of the project is to contribute to better measure, model, and predict the processes leading to earthquakes, landslides, submarine slides, and tsunamis, and of their effect in terms of hazard. The main strategy is to take advantage of an exceptional natural laboratory in Europe for studying these natural disasters: the rift of Corinth in Greece, and to benefit from the knowledge, data bases, and monitoring arrays of previous European projects in the area (Fig. 1). The selected region is a 30 x 30 km2 area at the western end of the rift, where the seismicity and tectonic strain rate is the highest. It is located near the western limit of the faults ruptured by two recent, destructive earthquakes (Galaxidi, M=5.8, 1992; Aigion, M=6.2, 1995).

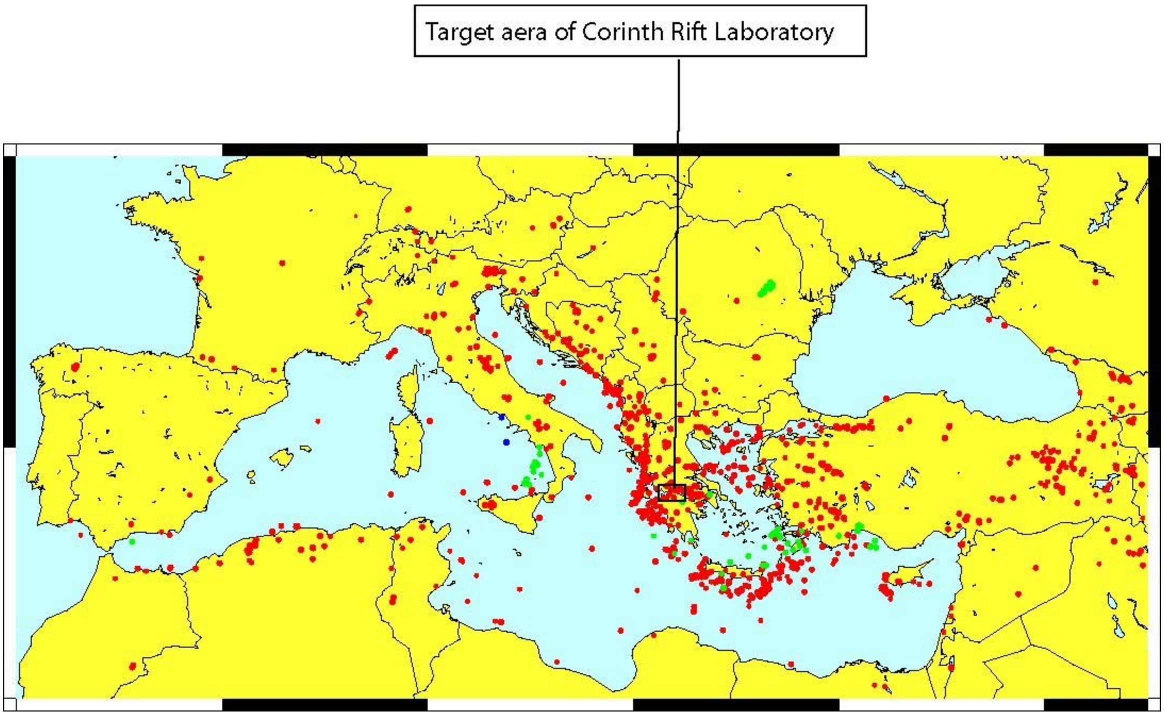


Fig. 1 : Earthquakes M>5 of the Mediterranean region 1960-2003

The rift of Corinth has been long identified as a site of major importance for earthquake studies in Europe, producing one of the highest seismicity rates in the euro-Mediterranean region: 5 earthquakes of magnitude greater than 5.8 in the last 35 years, 1.5 cm per year of north-south extension, frequent seismic swarms, and catastrophic historical earthquakes (Armijo, 1996; Rigo, 1996; Briole, 2000; Bernard et al., 1997; Makropoulos and Burton, 1985, Makropoulos et al.,1989, Papazachos and Papazachou, 2003). In the last decade it became the target for a large international effort on earthquake research, mostly at the European level, leading in the last few years to the development of the Corinth Rift Laboratory (CRL) project, concentrated in the western part of the rift, around the city of Aigion. (Cornet et al., 1997, 2001; WEB: http://www.corinth-rift-lab.org; Moretti et al., 2001). A special issue of the *Compte-*

Rendus de l'Académie des Sciences provides 24 refereed papers describing the most recent discoveries and on-going work of CRL (CRAS, 2004).

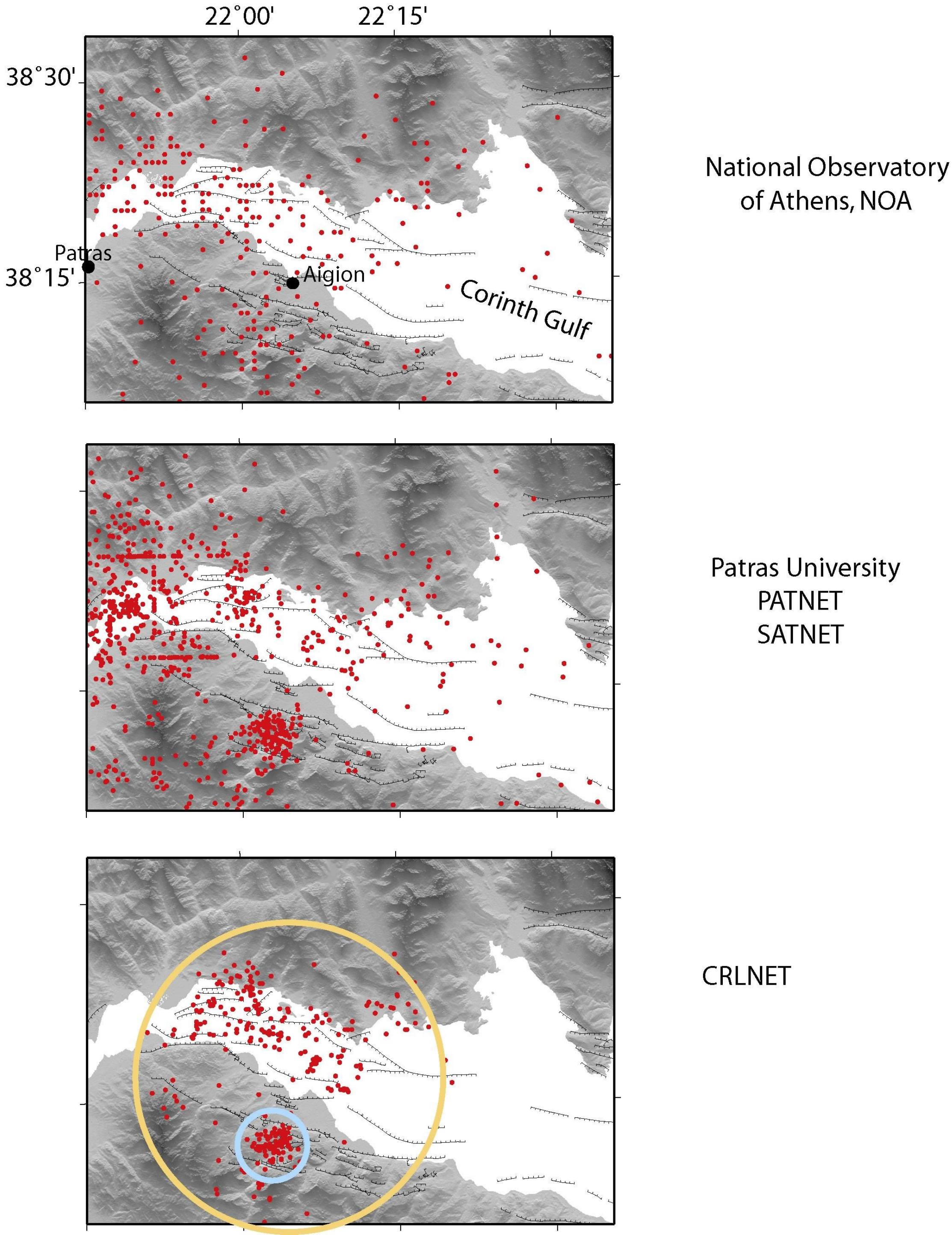


Fig. 2 : Earthquakes from PATNET catalogue from Jan. 2001 to June 2003
Top: all earthquakes from the PATNET catalogue located by NOA. NOA locates only the largest events. Bottom plot: only earthquakes from the PATNET catalogue within the array (yellow circle), located by CRLNET. Note the better focussing of some clusters (e.g., blue circle: spring 2001 swarm). Smaller magnitude earthquakes well located by CRLNET are not plotted (about 5 times more).

But earthquakes are not the only risk for the Corinth Gulf area. The rifting causes the fast subsidence of the offshore rift center, producing unstable river deltas offshore. This often leads to submarine slope failure and to damaging tsunamis (Papadopoulos, 2000). On land, the same fault system is rapidly uplifting poorly consolidated sediments. This often causes damaging landslides. In addition to the tectonic cause of instability, the Gulf of Corinth experiences fast and drastic water level changes. Indeed the Gulf has been isolated from the Aegean sea about 300 000 yr ago, and the westward connection to the Mediterranean, the pass at Rio-Antirio, is only 60 meters deep. The Gulf is thus periodically a lake. The last marine invasion is only 13 000 yr old (Lemeille et al., 2003). At that time the lake surface was about 75 meters below the current sea level (Lykoussis et al., 2003; Moretti et al., 2003). These water level changes, linked to the tectonics but also to the climatic changes, have a strong influence on both the submarine and the landslide slope stability.

Therefore, in addition to the liquefaction effects induced by shaking and to the large surface ruptures on the fault line, large earthquakes play an important role in the triggering of tsunamis, offshore slumps, and landslides. Let us recall the 373 BC earthquake and its associated devastating tsunami which totally destroyed and submerged the ancient city of Helike, or the 1817 earthquake, which produced high sea waves along the coast near Aigion and drowned several hundred people. But sometimes, no causative earthquake is reported, like in 1963 when an offshore slope failure caused a damaging tsunami, or in 1996, when a landslide blocked and damaged the Athens-Patras highway.

B.1.2 Seismic hazard:

For the seismic hazard, the main objective is two-fold, related to short term and to long-term processes.

B.1.2.a Short term seismic hazard

For time scales much smaller than the seismic cycle, i.e., less than a decade, the overall objective is to measure and model the basic physical processes leading to earthquakes, and the earthquake dynamics itself, with its potentially destructive radiated waves. This involves not only seismological tools, but also a complementary approach using geodesy, geophysics, and geochemistry.

Understanding the mechanisms leading to earthquakes requires to study the mechanical interaction of small and large earthquakes, for finding the conditions and respective roles of static and dynamic triggering (a subject which remains controversial; e.g.: Ziv, 2003; Gomberg, 2001). It also requires to model the cross-triggering of earthquakes with other dynamic geophysical processes: inter-seismic strain concentration, and strain and fluid "transients" (fault creep, crack growth and healing, pore pressure changes in faults and aquifers, and geochemical perturbations linked with fluid circulation). Information on fault geometry at depth and other structural parameters is necessary inputs. The reported and still controversial acceleration of seismicity before large earthquakes are probably related to these non-seismic processes.

The search for episodic or continuous fault creep or fluid flow at seismogenic depth is therefore one of the most promising and challenging issue for a global understanding of fault mechanics, and hence of earthquake generation and prediction (Nature Debate, 1999). A number of very recent publications report clear but puzzling observations of such transients (Rogers and Dragert, 2003; Obara, 2002; Pizzino et al., 2001; Quattrocchi et al., 2003).

In the Corinth rift, the most obvious expression of transient is the occurrence of seismic swarms, as one or two per year are observed in the target region. Their origin remains unknown: mechanical cross-triggering, natural hydro-fracturing, or aftershocks following a "silent" earthquake. Some other transient anomalies were also detected on the radon (Pizzino et al., 2003), geochemical and hydrological (Leonardi et al., 2003; Quattrocchi et al., 2003) sensors, and their relationship with earthquakes is presently being investigated. Their possible correlation with "silent" earthquake at depth remains speculative, as no accurate strain measurement was available at the time. More recently, in December 2002, a strain transient was recorded on a newly installed, high-resolution borehole dilatometer (Fig. 3). It lasted one hour, and peaks, within seconds, at the time with a moderate, nearby earthquake. The latter may thus have been triggered by a much larger scale aseismic fault slip (Bernard et al., 2003). However, only one such instrument was operating, so that an independent, closer source of the anomalous signal cannot be ruled out. The recent and planned improvement of the observational arrays of CRL, in particular the borehole strainmeter array, is expected to produce many more interesting signals in the coming years, which may eventually and hopefully be correctly explained.

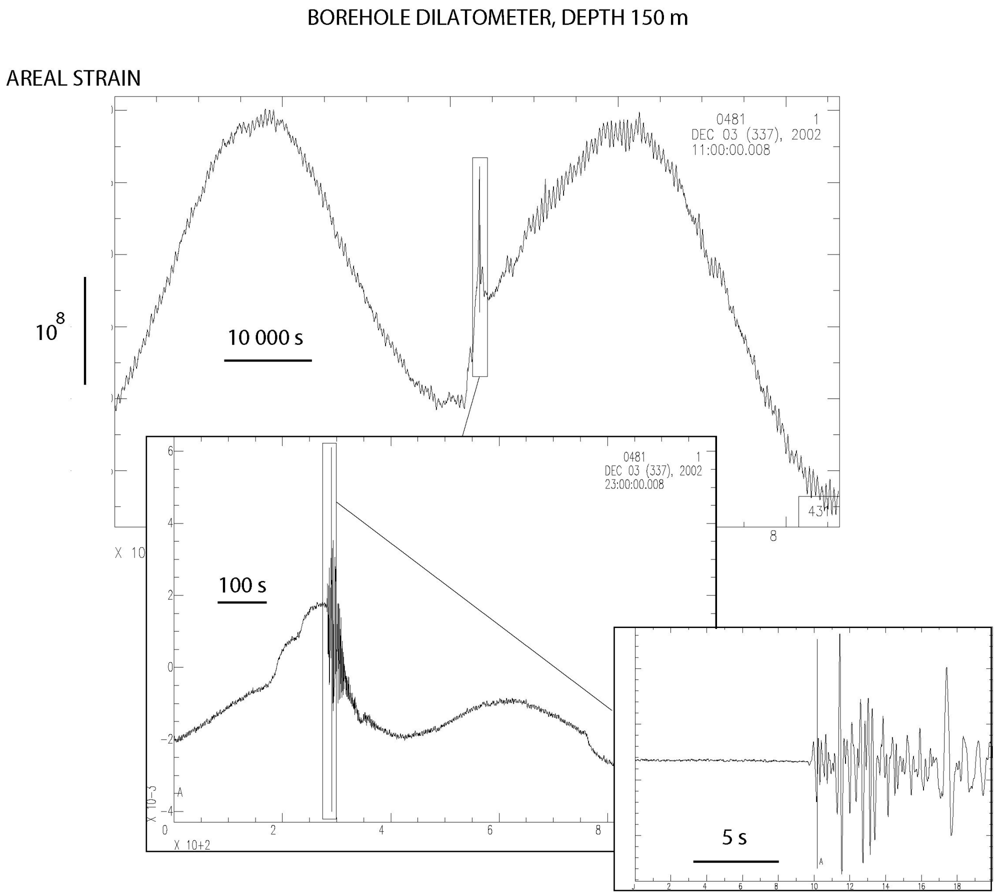


Figure 3: The 3 December 2002 strain transient in Trizonia
Top: the one hour transient is superposed on the earth tide signal
Bottom: the maximum of strain anomaly coincides with the arrival time of seismic waves for a magnitude 3.5 earthquake , 10 km to the west. If colocated with the earthquake, the strain event has a moment magnitude of 4.5.

The first objective for the short term hazard study of the project is therefore to maintain and improve the CRL multi-scale, multiparameter surface and borehole arrays. These arrays consist of various sensors (short period and broadband seismometers, accelerometers, continuous GPSs, borehole strainmeters, long base tiltmeters, ground water pressure at different depths, temperature and geochemistry measurements, electro-telluric arrays, magnetometers,…), whose continuous data flow will be available from our data bases (see Fig. 4 and 5, and Table 1 in B.4.2). The latter include the water pressure records obtained since September 2003 in the CRL, 1 km deep borehole observatory AIG10, installed within and near a major fault zone crossed by the borehole.

The high level of swarm activity at the western end of the rift, near the Psathopyrgos fault, the related higher seismic hazard (see next paragraph), and the depletion of CRL instruments in this area (CRL is up to now focussed more to the east, around Aigion city), lead us to propose to reinforce the CRL arrays in this area. This will be essential for achieving the integration of the data for an effective modelling of the recorded processes.

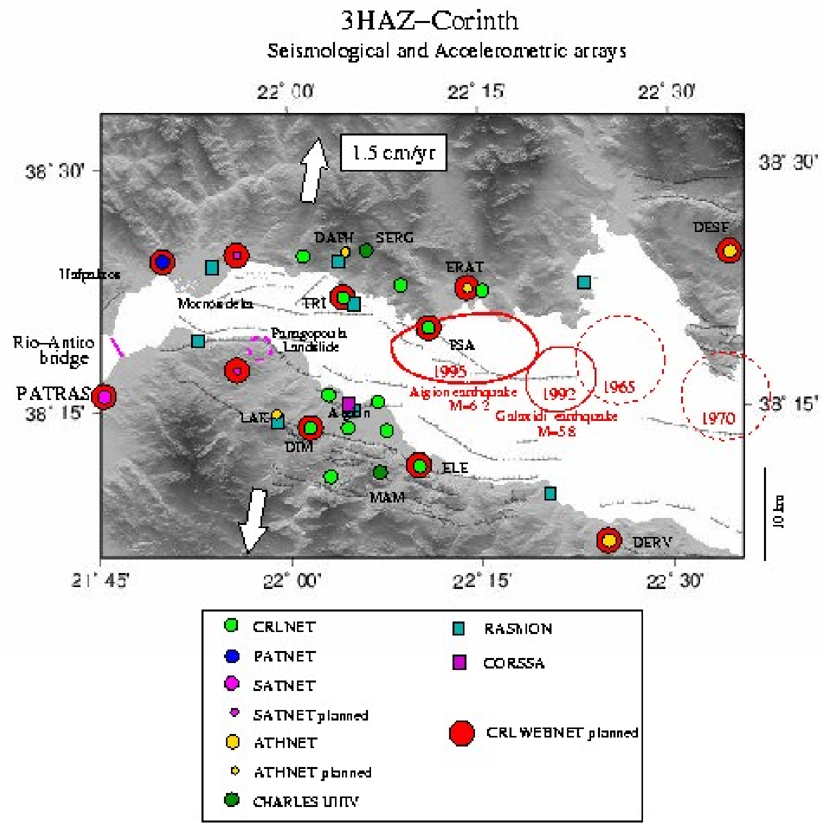


Fig 4: Seismic arrays

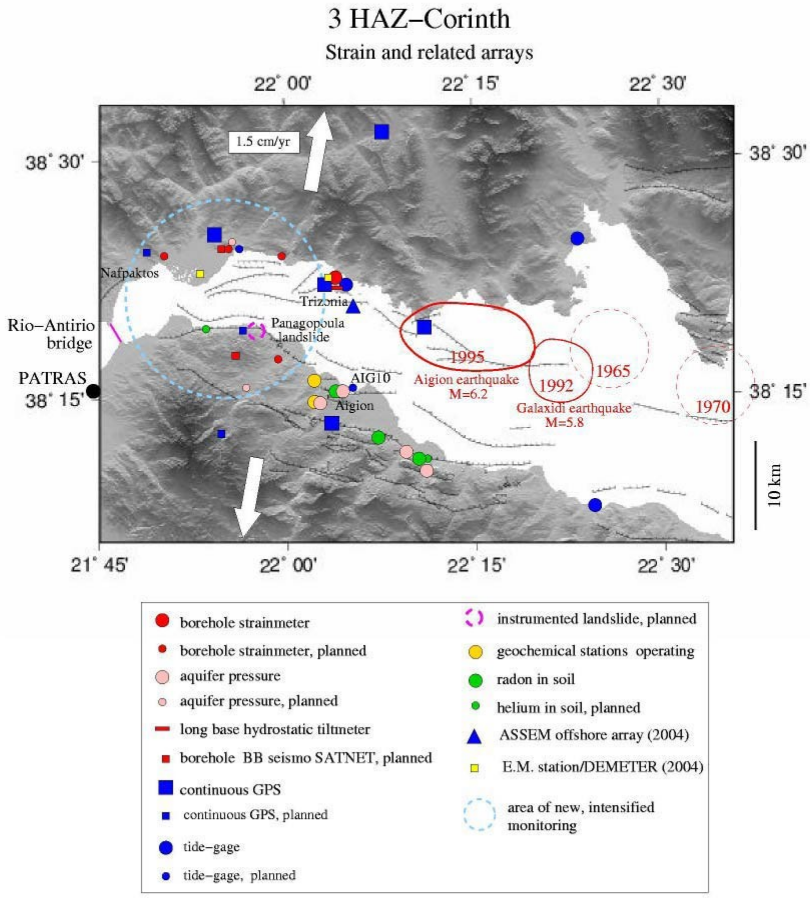


Fig. 5: Strain-related arrays

The second objective is to analyze, cross-correlate, and model the existing and future data of these CRL arrays, to progress in the understanding of earthquake triggering and interaction, and the cross-coupling of earthquakes with slow transients. The newly gathered data will allow to improve and complete the images of the crustal structure, through tomographic analysis. The resulting structural model of the upper crust and fault geometries at depth will help constraining and understanding the observed mechanical processes.

Local or regional moderate to large earthquakes will deserve particular attention, for analysing their sources (fault complexity, directivity), and their static and/or dynamic effects in terms of triggered phenomena (seismicity and other transients, including surface ones: surface faulting, liquefaction, non linear response of soils, tsunami and slope failures). In particular, accelerograms on the CORSSA, soft soil borehole array (Aigion harbour) show that weak motion is amplified by a factor of 5 to 15 when reaching the near-surface (Fig. 6). The soil non linearity should reduce this amplification for strong motion, but none is recorded yet. Such future records and their modelling will contribute to improve the present seismic regulations.

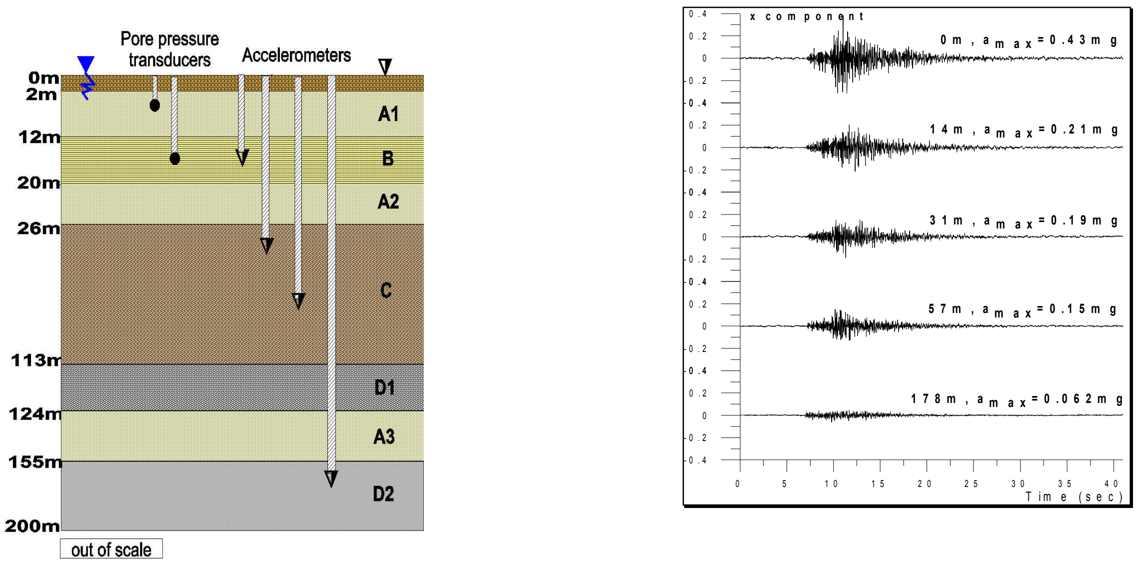


Fig. 6: Amplification of weak motion seismic waves by soft soil revealed by CORSSA, Aigion harbour (CORSSA data base)

Models will be developed for a reliable prediction of strong ground motion. This first requires to precisely identify the possible causative faults, which is in progress (see B.1.2.b). The numerical simulations based on stochastic description of extended sources (k-square model, composite model, Empirical Green functions) are not yet satisfactory. One major problem is the proper modelling of the directivity effect, and of its frequency dependence (e.g., Bernard et al., 1996). In the rift, the major normal faults dip towards north under the Gulf. Hence, Aigion and Patras cities, located to the south, are in the direction of future propagation of ruptures, with a maximal amplification due to directivity which has to be properly evaluated (see Bernard et al.(1997) for the effect of the 1995 Aigion earthquake).

Finally, the reliability of near-real time alarms from selected seismic stations will be studied. Near-real time hazard maps will be produced thanks to the satellite telemetry of relevant monitored parameters, in particular from accelerometers. The results will be evaluated with the end-users (civil protection, local authorities, etc..).

B1.2.b Long term seismic hazard

For the long term seismic hazard, the first objective is to complete the CRL on-going studies of the seismic potential of the local active faults. These are focussing on searching and modelling their morpho-tectonic signature, using paleoseismological methods (trenching, shallow coring, studies of the uplift of marine terraces, dendrochronology, geochemistry …) (e.g., Pantosti et al., 2003; De Martini et al., 2003). The recent discovery of fresh scarps on offshore faults with high-resolution bathymetry leads us to propose a well focussed, submarine investigation. These analyses will be coupled with the re-evaluation of historical seismicity records. The gathered data on fault segmentation and recent activation, and the related modelling of rupture dynamics will help to evaluate the probability for ruptures to jump from one segment to the next in a single earthquake, and thus to generate destructive events with magnitudes 6.5 to 7.

The studies conducted during the first years of CRL have emphasized the present reactivation of old structures, such as the Hellenic napes. It seems that the localisation of the earthquakes is for a large part explained by pre-existing discontinuities (Lyon-Caen et al., 2003; Le Pourhiet et al., 2003). This explanation has to be confirmed by a better 3D knowledge of the inherited structures.

Concerning the seismic hazard, an important question to be answered for the western edge of the selected area is why no report of large historical earthquakes exists (Papadopoulos, 2000; Papazachos and Papazachou, 2003). This, despite a relatively rapid opening rate determined by a decade of GPS measurements, and despite the presence of active faults with impressive morphological signatures. Would this be the sign of a recent acceleration in the rift opening, possibly as a precursor of a large earthquake? or, to the contrary, does it reveal a large aseismic component of the rifting? In both cases, this has important consequences on the physical processes at work in the upper crust, and also for the local seismic risk, as this area lies within 10 km of the city of Patras, and 5 km from the Rio-Antirio, 2.2 km long bridge presently under construction across the Gulf. The studies in this area also includes a proposal for offshore sampling and dating, for constraining the recent sedimentation rates, and hence the active fault slip rates.

B1.3 Submarine slope failures

For this hazard, the project aims first at documenting and mapping places of past and future submarine slope failures on the steep slopes of the active deltas, through the detailed analysis of the most recent and accurate sonar images and bathymetric maps (Lykoussis et al., 2003). We will search for correlation between the recent activity of offshore normal faults and the potential for slope failure on their foot wall, leading to empirical laws.

The second objective is to select one or a couple of the most recent slumps, and to investigate their correlation with recent or large historical earthquakes, by sediment sampling and dating. Scenarios of slope failure (location, size, velocity) will be developed for input to tsunami modelling

The monitoring of a submarine slope failure will not be considered in this project, as it is the subject of a presently running EC project, ASSEM, which is part of the CRL project cluster. However, ASSEM will produce in 2004 submarine geodetic data in the Gulf of Corinth with new technology: our project will analyse these data for assessing the feasibility of monitoring and detecting the sliding of a submarine slope.

Offshore slope failure will be monitored through their tsunami effect, detected by tide-gages, and, as a preliminary experiment, through their possible noise generation, detected by an hydrophone to be installed underwater.

.

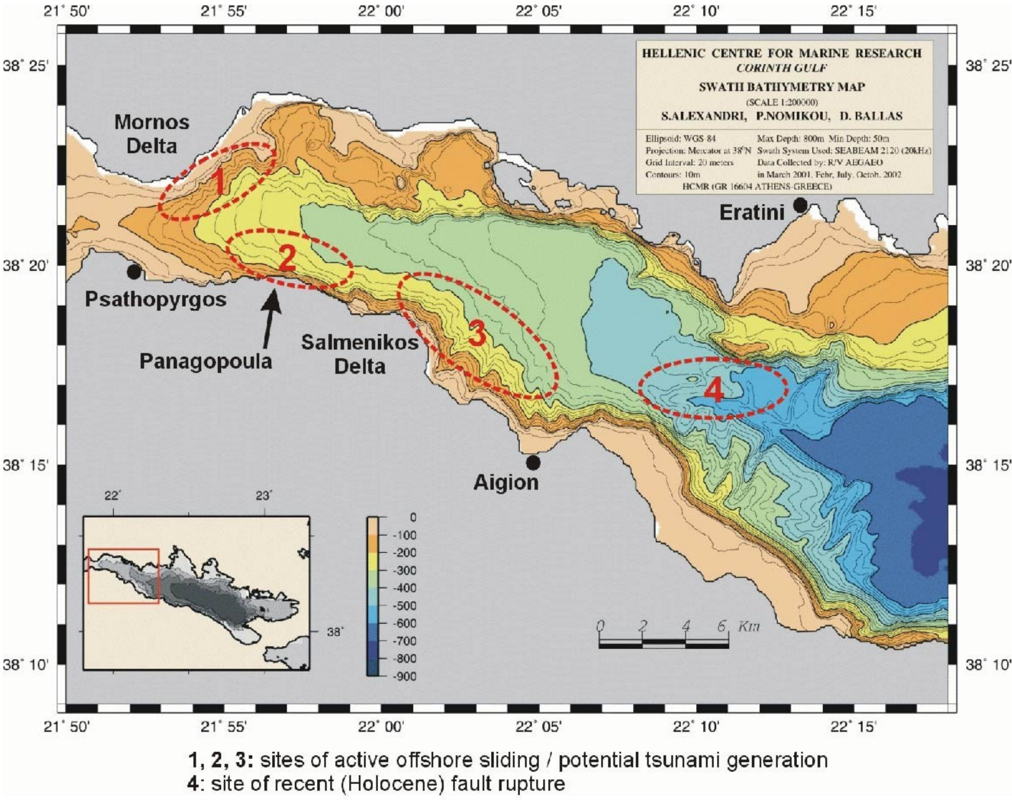


Figure 7

Bathymetric map of HCMR and offshore targets

B1.4 Tsunamis

The main objective is to calculate scenarios of tsunamis which can be produced by large earthquakes and offshore slumps described above. Numerical codes will be implemented using the high-resolution bathymetry provided by HCMR (Piatanesi and Tinti, 2002). The few years of data from the tide-gages around the gulf will be analyzed in terms of free oscillations, to control the validity of the tsunami code, and for searching for signals from small scale, yet unreported slumps. Historical (archives) and paleohistorical data (from sediment coring and dating in the lowlands of the northern shore) will be gathered to evaluate the frequency of the tsunami hazard (e.g., Papadopoulos, 2003; De Martini et al., 2003).

Our efforts will focus on the modelling of the wave run up enhanced by the shallow dipping sea bed near shore, threatening in particular the harbour of Aigion city. The complete tsunami modelling will allow to test the feasibility of early warning. Alarms will be tested in near-real time from tide-gage and seismic recordings.

B1.5 Landslides

The main objective is to monitor and model the perturbation of the sliding of a well documented active landslide in response to ground shaking from local earthquakes. This is an important issue, as many large landslides are triggered during earthquake shaking, and nothing is known on the destabilization process, due to the lack of appropriate measurements (Brodsky et al., 1999)

In the target area, there is only one major landslide, located on the scarp of a normal fault: the Panagopoula landslide, threatening the Patras-Athens highway, railway, and national road. This landslide is well documented and presently surveyed by a private geotechnical company. As this landslide may reach the shore line, as it did in 1971, it can trigger submarine slope failure and tsunamis, a scenario which will be studied. Data from previous investigations will be analysed for defining the optimal measurement locations. We will complement them with specific geochemical and geological field work. Some surveys are still on progress on this landslide (Survey for the Highway service; LEWIS, E.C. project; see B3.1), but none of these studies produce the space and time density of data required for our objective.

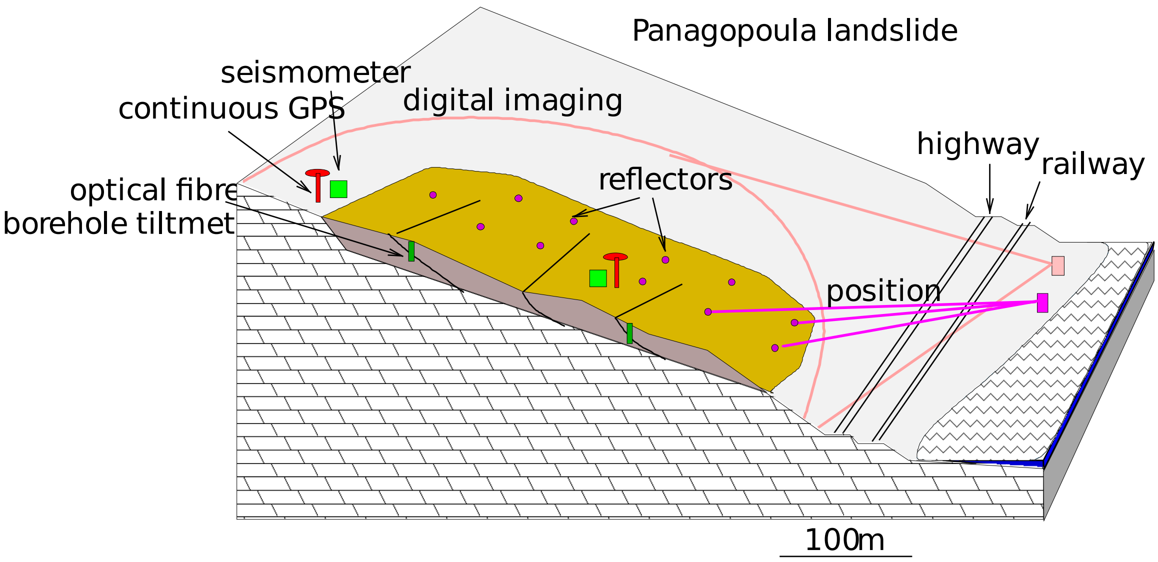


Figure 8: Sketch of planned instrumentation of the Panagopoula landslide

We thus propose complementary measurements. The sliding rates will be assessed by continuous GPS, and from repeated geodesy: correlation between repeated ground or air images, and tacheometry (distance and angle). Short term perturbations will be detected by GPS and seismometry (displacement, and seismic noise analysis). Local rain will be monitored as well, as it is the dominant triggering cause of landslides. The most relevant parameters for a real-time warning will be investigated (threshold on sliding velocity or acceleration), and alarm procedure will be tested. Slip rates and seismic waves will be integrated in dynamic models of landslides.

A second objective is the daily geodetic monitoring of the Corinth-Patras railway track, in the target area, through automatic, standard kinematic continuous GPS survey: the GPS is installed on the local train. This will allow the detection of the start of landslides and coastal slope failure, with a resolution of a few centimetres, in particular after large rain periods or moderate to large earthquakes. The possibility of daily or near-real time analysis will be evaluated, for triggering alarm systems and informing local authorities and transportation services.

A third objective is to study the long term coupling of landslides and submarine slope failures related to the changes of the water level in the rift. The two phenomena have to be studied together in the frame of the 3D models of sedimentation/erosion at the scale of the western tip of the Gulf. This modelling will take into account the tectonic uplift and subsidence, the water level changes, the climatic evolution and therefore the erosion and sedimentation rates. The calibration of the model by the data will allow to predict interaction between landslide and submarine slope failure.

B1.6 General multi-hazard assessment for end-users

The causative relationship between all hazards, revealed by the studies outlined above, will be further analysed for producing statistical and physical models of cross-triggering. These models will be integrated in a multi-hazard assessment frame. In particular, the results of the seismic, tsunami, and landslide near-real time alarms will be evaluated and discussed with the relevant end-users (civil protection, local authorities…).

References of the text:

Armijo R., Meyer, B., King, G., Rigo, A. and Papanastassiou, D., 1996, Quaternary evolution of the Corinth rift and its implications for the late Cenozoic evolution of the Aegean, *Geophys. J. Int.* **126**, 11-53, 1996.

Bernard, P., F. Boudin, S. Sacks, A. Linde, P.-A. Blum, C. Courteille, M.-F. Esnoult, H. Castarède, S. Felekis, and H. Billiris, Continuous strain and tilt monitoring on the Trizonia island, Rift of Corinth, Greece, *C.R. Acad. Sci.*,in press, 2003.

Bernard, P., A. Herrero, and C. Berge, Modeling directivity of heterogeneous earthquake ruptures, *Bull. Seismol. Soc. Am. 86,* 1149-1160, 1996.

Bernard, P., P. Briole, B. Meyer, H. Lyon-Caen, et al., The Ms=6.2, June 15, 1995 Aigion earthquake (Greece): evidence for low angle normal faulting in the Corinth rift, *Journal of Seismology 1,* 131-150, 1997.

Bernard, P., From the search of precursors to the research on crustal transients, *Tectonophysics, 338*, 225232, 2001

Briole P., Rigo, A., Lyon-Caen, H., Ruegg, J.C., Papazissi, K., Mitsakaki, C., Balodimou, A., Veis, G., Hatzfeld, D. and Deschamps, A., 2000, Active deformation of the Corinth rift, Greece: results from repeated Global Positioning System surveys between 1990 and 1995, *J. Geophys. Res. 105*, 25605-25625.

Brodsky, E.E., H. Kanamori and B. Sturtevant, A seismically constrained mass discharge rate for the initiation of the May 18, 1980 Mount St. Helens eruption, *J. Geophys. Res., 104*, 29:387-400, 1999.

Collier R., D. Pantosti, G. D'Addezio, P.M. De Martini, E. Masana, and D. Sakellariou (1998). Paleoseismicity of the 1981 Corinth earthquake fault: seismic contribution to extensional strain in Central Greece and implications for seismic hazard, *J. Geophys. Res*., 103(B12), 30,001-30,020.

Collier R.E., Leeder M.R., Rowe P.J., Atkison T.C., 1992. Rates of uplift in the Corinth and Megara basins, central Greece, *Tectonics, 11,* 1159-1167.

Cornet F.H., G. Borm, T. Mc Evilly & I. Vardoulakis; 1997; Proceedings of the workshop on the development of a multiborehole observatory at the Gulf of Corinth; accessible from www.corinth-rift-lab.org

Cornet F.H., I. Vardoulakis, I. Moretti, P. Bernard and G. Borm; 2001; Proceedings of the CRL Aigion Workshop; accessible from www.corinth-rift-lab.org

C.R.Ac.Sc.-Geosciences, Special Issue (24 papers), to appear February 2004.

De Martini P.M., D. Pantosti, N. Palyvos, F. Lemeille, L. McNeill, R. Collier (2003): Slip rates of the Aigion and Eliki faults from uplifted marine terraces, Corinth Gulf, Greece, *Geosciences*, in review

del Gaudio, V., P. Pierri and Wassowski, An approach to time-probabilistic evaluation of seismically induced landslides hazard, BSSA, 93,2, 557-569, 2003.

Gomberg, J., The failure of earthquake failure models, *J.Geophys. Res.,106,* 16253-16263, 2001.

Lemeille F., Sorel D., Bourdillon C., Guernet C., Manakou M., Berge-Thierry C., 2002. Quantification de la déformation associée à la faille d'Aigion (Golfe de Corinthe, Grèce) par l'étude des dépôts du Pleistocène supèrieur et de la transgression marine holocène. *CRAS, 334,* 497-504.

LePourhiet, L., Burov, E. & Moretti I., The use of inherited structures dureing extension (study case in the Gulf of Corinth), 2003, submitted to Tectonics.

Leonardi V., Gavrilenko P. & Marchioni H. - Impacts des marées terrestres et de l'activité tectonique sur les eaux souterraines (Golfe de Corinthe, Grece). In *IAHS Publication n°278 "Hydrology of mediterranean and semiarid regions",* Montpellier, France, 1-4 avril 2003, 2003

Lykousis V, Sakellariou, D. and Rousakis G., 2003. Prodelta slope stability and associated coastal hazards in tectonically active margins: Gulf of Corinth (NE Mediterranean).In: *J. Locat and J. Mienert (eds) Submarine Mass Movements and their Consequences* pp. 433-440.

Lyon-Caen, H., P. Papadimitriou, A. Deschamps, P. Bernard, K. Makropoulos, F. Pacchiani, G. Patau, First results of CRLN seismic array in the western Corinth rift: evidence for old fault reactivation, *Compte-Rendu Ac. Sci,* in press, 2003.

Makropoulos , K., and Burton, P.W., 1985. Seismic hazard in Greece: II ground acceleration. *Tectonophysics, 117*, 259-294.

Makropoulos, K., Drakopoulos, J., Latousakis, J., 1989. A revised and extended earthquake catalogue for Greece since 1900. *Geophys. J. Int., 98,* 391-394

Moretti , I., D. Sakellariou , V. Lykousis, L; Micarelli, 2003. The Gulf of Corinth : a half graben ? *Journal of Geodynamics. 36,* 323-340.

Nature Debatse, 1999, Is the Reliable prediction of individual earthquake a realistic scientific goal, *http://www.nature.com/nature/debates/earthquake/equake_frameset.html*

Obara, K., Nonvolcanic deep tremor associated with subduction in Southwest Japan, *Science, 296,* 1679_1681, 2002.

Pantosti D., R. Collier, G. D'Addezio, E. Masana and D. Sakellariou (1996). Direct geological evidence for prior earthquakes on the 1981 Corinth fault (central Greece), *Geophys. Res. Lett*., 23(25), 3795-3798.

Pantosti D., P. M. De Martini , I. Koukouvelas, L. Stamatopoulos, N. Palyvos, S. Pucci, F. Lemeille, S. Pavlides (2003): Paleoseismological investigations of the Aigion fault (Gulf of Corinth, Greece), *Geosciences*, in review

Papazachos, B., and Papazachou, K., 2003. The earthquakes in Greece, third edition, pp286.

Papadopoulos, G. A., 2000. Historical earthquakes and Tsunamis in the Corinth Rift, Central Greece. *National Observatory of Athens, Institute of Geodynamics, Publication No. 12*, 2000.

Piatanesi A., Tinti S., 2002, Numerical modeling of the September 8, 1905 Calabrian (southern Italy) tsunami, *Geophys. Jour.**Int.***, **150, 271**-284.

Pizzino L., Quattrocchi F., Cinti D., Galli G.. (2003). Fluid Geochemistry along the Eliki and Aigion seismogenic segments (Gulf of Corinth, Greece). *C. R. Acad.Sci.Paris, Sciences de la Terre et des Planètes,* in Press, 2003.

Quattrocchi F., Favara R., Capasso G., Pizzino L., Bencini R., Cinti D., Galli G., Grassa F., Francofonte S., Volpicielli G. (2003). Thermal Anomalies and fluid geochemistry framework in occurrence of the 2000-2001 Nizza-Monferrato seismic sequence (Northern Italy): episodic changes in the fault zone heat flow or chemical mixing phenomena? *Natural Hazard and Earth System Sciences*, 3, 269-277.

Rigo, A., Lyon-Caen, H., Armijo, R., Deschamps, A., Hatzfeld, D., Makropoulos, K., Papadimitriou, P. and Kassaras, I., 1996, A microseismic study in the western part of the Gulf of Corinth (Greece): implications for large scale normal faulting mechanisms, *Geophys. J. Int.* **126**, 663-688.

Rogers, G., and H. Dragert, Episodic tremor and slip on the Cascadia Subduction: The chatter of Silent slip*, Science, 300,* 1942-1943, 2003.

Ziv, A., Foreshocks, Aftershocks and remote triggering in quasi-static fault models, *J. Geophys.Res., in press*, 2003.

B.2 Relevance to the objectives of the Global Change and Ecosystem Sub-priority

B.2.1 Scientific, technological, and societal policy objectives of the sub-priority

- The better understanding of processes leading to earthquakes, tsunamis (“coastal flood”), and landslides, to which the project will contribute, will allow a better modelling of their mechanics, and improve the quality of their prediction and of the assessment of the related hazard.
- The project has a strong applied component useful for end-users :
    - detailed hazard scenarios will be produced for the area under investigation
    - near-real time alarms
    - data bases for easy public accessibility of data
    - damage assessment in near-real time will be developed for seismic and tsunami hazard.
    - Improved modelling of soft-soil amplification and non-linearities, with application to seismic design spectra
- Data from already existing instruments will be fully employed
- New instruments are developed for a better monitoring of natural hazards
- Data from multisensor patforms and arrays (ground, borehole, submarine, and satellite) will be integrated in data bases and models
- Improvement of the basin modelling tools of IFP to the smaller time scale (some of the algorithms, especially for erosion, need to be adjusted)

B.2.2. Other priorities in global change and ecosystems

- ***Dynamics and climatic variability; new methods and paleoreconstruction, I.1.3.c***
  - Sedimentation/erosion signal in the Gulf . As a close marginal sea, the Gulf has been very sensitive to all the climatic evolutions. The synrift sediments are only 1 myr old and reach a thickness of 2.4 km. They provide a very precise record of the climatic evolution on the area for the recent period.
- ***Protection and restoration of soils and groundwater, II.2.2.b***
  - "Characterization and monitoring of groundwater sites", through the continuous monitoring of aquifers at several sites, in particular on the Aigion cultivated plain.
  - Geochemical and mechanical interaction of faults and fluids: a fault can act as a permeable drain or as an impermeable barriers, with important consequences for water resources and pollution. Recent results of deep boreholes and field work by CRL teams reveals a "barrier" effect in the Aigion area.
  - Perturbation of ground water by earthquake rupture: changes in fault zone permeability may connect previously separated reservoirs and modify local water resources.
- ***Cooperative forecast and modelling, observations of system earth, VI.1.b***
  - Contribution to integrated observation systems, including space data (DEMETER satellite, InSAR, GPS)
- ***Tools for environmental monitoring, VII.2.2***
  - High-resolution sensor will be developed for monitoring ground deformation.

B.2.3. Priorities other than 1.1.6.3

- ***Contribution to GMES, 1.1.4***
  - Development of near-real time alarms through satellite communication
  - Data base accessibility on the net
  - Combination of ground based with satellite based monitoring
  - Contribution in standardisation and harmonisation of natural hazards related environmental data (raw data, alerts, maps etc); exchange among research institutes, governmental agencies, local authorities and general public
- ***Improving risk management, 2.3.2.1***

  The observations and models of hydro-mechanical processes in the crust and of the related triggering of earthquakes will help to assess the risk of induced seismicity related to CO_2 storage and oil pumping

B.3 Potential Impact

B.3.1 Strategic impact:

- Global strategy of the Corinth Rift Laboratory (CRL) project

The present project is a major element in the global CRL project. It is thus embedded in its general strategy: to gain an international recognition as a major test site for fundamental and applied research on earthquake and related hazards, and attract research groups from many European institutions and research areas. It already attracts the engineering community (soil mechanics, structural engineering, …), the private industrial research centers and geophysical companies (IFP, Schlumberger, …), institutions in charge of nuclear power plant safety control (IRSN), and national marine research centers (IFREMER in France, HCMR in Greece). The new input with slope failure and tsunamis should attract a wider community.

The present project should provide the relevant data base and long term monitoring structure (observatory) to welcome new and presently unforeseen experiments related to the targeted hazards, and become an international, multi-hazard Research Center and Observatory.

If a significant earthquake happens during the 3HAZ-Corinth project period in the Corinth Gulf, or in the future of CRL, the existing and planned instrumentation will make it one of the best understood events worldwide. This would have a direct impact on improvement of the seismic zonation and building codes through the strong motion measurements. It would also provide an exceptional data base for analyzing in detail any precursory phenomena, and the poorly know mechanisms of postseismic response and recovery.

The high seismicity character of the Corinth rift makes it the best place in continental Europe to study the related processes and cross-triggered hazards. The development of instrumentation method, advanced data analysis, and new modelling techniques can thus progress more rapidly there than in any other site in Europe, and, in return, benefit European countries where the seismic risk is moderate.

In particular, the clear increase of seismicity in northern Europe due to oil pumping in the North Sea and possibly, in the near future, due to the planned storage of CO_2 in underground reservoirs, is changing the seismic risk. The proposed study in 3HAZ will bring new data and models concerning hydro-mechanical processes in fault zones, and hence contribute to a better monitoring and control of this triggered seismicity.

- Competitiveness of CRL and 3HAZ-CORINTH

The main ingredients for making and strengthening the competitiveness of the project and increasing the chances of its successful development are briefly listed below:

- **Unique site** for the planned studies (regular and strong seismic activity, triggering of other hazards, easy accessibility).
- **Large seismic data base**, increasing and improving (short period, broad band, strong motion)
- **Unique geophysical data base**, increasing and improving, with a multiparametric approach, **on land, offshore, in deep boreholes, and on satellite** (GPS, strainmeters, tiltmeters, ground water,

geochemistry, magneto-telluric, DEMETER Satellite). None like this in a single area in Europe.

- **Large geological data base**: number of the faults have been accurately mapped, studied and dated, hundreds of thin sections have been done and analysed. The fracture networks are known around the main faults (Doumena, Pirgaki, Helike, Aigion, Lakka, Trizonia …) of the area. Trenches have been dug across some of them to describe their recent evolution. Five offshore long piston cores from the Marion Dufresne Vessel have been obtained.
- **New data base from a deep borehole** (1 km) instrumented within a fault zone (only two other equivalent instrumented boreholes in the world, in California and Japan).
- **Innovative technology** for monitoring: high-resolution long-base bi-liquid hydrostatic tiltmeters (demonstration), low-cost high-resolution borehole strainmeter and tiltmeters (prototype development). These will have many applications in the geophysical sector (monitoring of faults, volcanoes, landslides) and in the industrial sector (geotechnics, civil engineering).
- **New concepts in earthquake studies**: shift of research target, from traditional, empirical studies of earthquake precursors (and the associated, controversial short term prediction) to mechanical studies of strain and fluid crustal **transients**
- **New target in earthquake studies**: documenting and modelling the **role of fluids** in fault mechanics
- **Competition with USA and Japan**: although the scientific and technological approach is similar in these countries (despite significant differences in the budget …), the CRL project appears complementary, as it works in an area with extension tectonics, clearly different from strike-slip (California) and thrust/subduction (Japan) environment. The geological, stress, and crustal fluid environment is significantly different, which may result in different mechanical and transient processes.

- The CRL deep drilling project

One important, medium term, strategic goal of CRL is the drilling of a deep, instrumented borehole reaching the seismogenic depth, around 5 km, in the target area. The success of the presented project, as part of CRL, is therefore a requested condition for an adequate preparation and justification of this drilling, and for increasing the chances of its acceptance at national and European levels.

It would be the first time that a seismogenic zone will be reached and instrumented in Europe, and possibly in the world. The only existing scientific, instrumented deep borehole is in Germany, reaching 9 km in depth; but the region is not seismic. In seismic zones, ambitious drilling projects are supported in Japan and California, but not achieved. In Japan, the presently instrumented boreholes in fault zones reaches 1500 m (Nojima fault, 1995 Kobé earthquake). At Parkfield (California), the pilot hole (2.2 km) near the San Andreas fault is completed and instrumented since 2003, for consolidating the project of a nearby 3.5 km borehole which should cross the San Andreas fault (SAFOD project, San Andreas Fault Observatory at Depth). These drilling projects, aimed at penetrating fault zones, are the only way to reveal the role of fluids in the mechanics of faults and in the triggering and inhibition of earthquakes, and to measure stresses *in situ.* Presently, thanks to the CRL project, Europe is still competing on this major target for earth sciences.

- European Added value

The project takes benefit of the variety of approaches, skills, and know-how of the many European institutions which develop earthquake, tsunami, and landslide research: instrumentation, drilling, monitoring, data transmission, data bases, data processing, inversion techniques, and, finally, numerical and theoretical developments on mechanics, hydrology, electromagnetism, geochemistry, physics and geochemistry of rocks, of faults, and of fluids.

- Societal problems

- ***Short term Earthquake prediction***

Short term prediction is an unavoidable societal question when dealing with earthquake research. It is also the subject of controversy, both in scientific and media debates. Unfortunately it can also give science a bad name. In particular one has in mind the VAN controversy, about the statistical and geophysical significance of a number of predictions based on the record of anomalous electro-telluric signals recorded at some sites. One of their latest predictions, in September 1999, a major earthquake which would hit the region north to Athens, was announced by the VAN group on television, creating panic there as well as in Athens: it was issued just a few days after the 1999 earthquake which severely damaged the north-western part of the city. The prediction was a false alarm. No scientific justification of this alarm was ever published in refereed journals afterwards.

The position of the CRL group on this topic is that there is no justification to issue a public warning from the observation of geophysical anomalies (swarms of small earthquakes, strain or fluid transient, electromagnetic signal, etc…), which may be precursors to earthquakes, as most of the time these transients die out without any subsequent large earthquake. This question needs a probabilistic approach, based both on statistics and on modelling, which is presently little developed. The probability that transients reveal or trigger earthquakes, and why, is a key question, to which our project will contribute finding answers. Schemes for probabilistic earthquake prediction will be tested on the data, looking at the statistical correlation between local earthquakes and recorded anomalies, and modelling them. This is a prerequisite step in the direction of short term earthquake prediction. But this approach is not straightforward for the public, which is much more sensitive to the brutal and simplistic announcement, on TV, radios, or newspapers, of a coming catastrophe. There will thus be no public announcements of imminent earthquakes from CRL. However, our group will take the opportunity of all media occasions for explaining our approach to practically-oriented research about natural hazards, as done in the past with films and conferences.

- ***Immediate and near-real time alarm***

The only moment when seismologists are sure that a destructive earthquake is on the way is when the first couple of seconds of the P waves from the main shock are detected on the closest seismometer. The real-time analysis of its amplitude and frequency content can reveal its magnitude, which can be instantaneously broadcast to selected end-users in the Aigion and Patras area (civil protection, firemen, fast train service, Rio-Antirio bridge service, …). This alert can arrive 5 seconds before the destructive S waves, depending on the distance, which is a small but possibly useful delay for some critical, automatic safety measures to be launched.

However, the heterogeneity of the presently operating seismic acquisition systems makes this real-time alarm very difficult to achieve. We propose a more modest objective of near-real time alarm – seconds to minutes delay – , useful for fast damage assessment and post-disaster planning of safety operations. Near-real time alarm systems will be installed and tested, based on selected seismic stations using satellite telemetry. This will produce not only seismic damage maps, but also coastal flooding maps due to related tsunami. End-users will be identified, and will contribute to the global evaluation of the system. The results will allow assessing the feasibility of real-time alarms based on single systems.

- ***Short term prediction for tsunami and landslide hazards***

The problem of public announcement is different for non-seismic hazards. For tsunami triggered by earthquakes or by large slope failure, it happens that due to the downward motion of the sea bottom in both cases (due to the normal fault geometry in the rift), the first motion on the coast is mostly downward: the sea is moving away with no damage. The returning, damaging sea wave is expected to arrive about five minutes after this first motion, which leaves time for public warning and safety measures. The feasibility and interest of local near-real time alarms inferred from tide-gage signals will be investigated.

For the landslide, which has unknown dynamics, the problem is different. The observation of slip rate acceleration does not necessarily mean the triggering of an imminent catastrophic failure. The reliability of recorded parameter thresholds for issuing an alarm will be studied. The daily GPS survey of the Corinth-Patras railway track will increase the safety of the traffic and warn about initiation of slope failures.

- ***Societal benefits for Greece***

All hazard maps and alarm-triggered scenarios, produced throughout CRL and in the present project, will be communicated and discussed to the relevant authorities in charge of the safety of the population, at the regional and national level. Due to earthquake awareness in Greece, and to the related respect of seismology, there is a high chance that scientific results will be immediately applied in technology (future operational warning systems, aseismic design).

- Exploitation/dissemination

- Scientific publications/conferences
- data center(s)
- CRL web site
- training center, in complement to the AEGIS project of CRL.
- Trough conferences and films (CNRS), information and education of the public on:
  - earthquake risk and related natural hazards, and public protection
  - the meaning and development of geosciences
  - the link between fundamental and applied research

- Links with and impact on other national/international projects:

- ***Corinth Rift Laboratory (CRL)***
  - The French research groups working on CRL are coordinated through a structure depending on the French CNRS, the “GDR-

Corinth”, which provides expertise, evaluation, and financial support for the CRL sub-projects.

- 3HAZ-CORINTH is strongly linked to ongoing, or recently completed CRL projects: CORSEIS (deployment of seismological, geophysical, geochemical arrays, tectonics), DGLab-Corinth (deep instrumented drilling, 1 km), ASSEM (offshore monitoring of earthquakes and landslide), 3F-Corinth (analysis and modelling of the interaction between faults, fluids and fractures), AEGIS (mobility and training on data mining). These projects work as a cluster: share of instruments, share of data, share of know-how, common conferences, and common publications. All participants of CRL are not in 3Haz-Corinth: in particular GFZ-Potsdam, despite its instrumented borehole in the Trizonia Island, but collaboration still continues within the cluster.
- ASSEM: the first year results, end of 2004, will guide the redeployment of the submarine geodetic system, in particular for offshore slope failure monitoring.
- Deep drilling in Corinth: the CRL long term effort is in particular devoted to the project of a deep, instrumented scientific borehole reaching the seismogenic depth (> 5 km). Several projects will be submitted to the commission in 2004 and after, for this purpose. This will require, as an input, the results and deliverables (data base, models) of our project.

o ***HELIKE***

The HELIKE project is an international archeological project, coordinated by the American School of Athens. It is aimed at discovering and excavating the remains of the Ancient Helike, a rich city which was destroyed in 373 B.C. by a large earthquake and its tsunami, located in our target area. Geophysical and geological studies have recently allowed to find the first major buildings of the ancient city. CRL will contribute to, and also benefit from this project, through a better analysis of the 373 B.C. earthquake and of its effect (in particular the tsunami), and through the discovery of archeological or geological evidence of other historical earthquakes.

o ***DEMETER***

DEMETER is the first micro-satellite which will be launched by the French Space Agency CNES, in 2004. It is the outcome of a 10 years R&D effort, aiming at a continuous monitoring of the electro-magnetic environment of the earth, focussed on earthquake and volcanic activity, mostly for the detection of precursors. CNES supported the installation of a “ground segment” with an array of various electromagnetic sensors in the CRL target area.

o ***LEWIS***

LEWIS is an E.C. project which started in 2002, focussed on landslide surveys, and a component of the “Earth Observation Systems”. One of the target landlside is the Panagopoula landslide. The space segment is the analysis of satellite radar and optic images. The ground segment has historical, geological, and instrumental components. The latter consists of accelerometers for detecting slope failure. Our project proposes a ground-based, complementary approach: repeated image correlation and tacheometry, continuous GPS, continuous tilt, weak motion measurement. After completion of both projects, taking into account the contractual dissemination level of their deliverables, we will propose a formal agreement for data exchange and coordinated work and analysis. It should be emphasized that our project remains self-consistent, and does not rely on the availability of LEWIS deliverables.

- ***ANMRA***

  ANMRA (Analisi e Monitorragio dei Rischi Ambientale) is an Italian "centro regionale di competenza", which proposes a multi-risk environmental project in the Campania region (earthquake, volcanoes, water, …), involving geophysicists, engineers, architects, and end-users. The center was launched in 2003, and is presently supported by regional funds and the EC. Preliminary discussions between leaders of ANMRA and of CRL provided strong expression of interest for the development of exchanges (data, models, know-how, training). Future common work could be integrated in the FP6 policy through dedicated projects

- ***ORFEUS:***

  The high-quality broadband records of the broadband Trizonia STS2 will be sent in quasi-real time to the ORFEUS Center (Observatories and Research Facilities for European Seismology), for public near-real time access of data and in case of earthquake with magnitude greater than 5 (European project MEREDIAN)

B.3.2 Contributions to European regulations

The amplification/attenuation of strong motion records obtained with the CORSSA, soft soil accelerometric borehole array, and the related response spectra, will be used for improving the design spectra for soft soils defined in EUROCODE.

B.4 The consortium and project resources

B4.1 Role of participants

IPGP, coordinator

Skill: The Department of Seismology of Institut de Physique du Globe de Paris has a long expertise in seismology, geodesy, and geophysics, with the development of new instrumentation, methods for data analysis, and theoretical/numerical modelling. It is the leader of the CRL project.

Main role:
Geodesy: maintain the GPS array, install 2 continuous GPS, analyse and model their data, produce and analyse InSAR images.
Seismology: data base for the CRLNET array, seismic source studies (multiplets, stochastic broad band simulation of large earthquakes, seismicity patterns)
Transients: operate the existing borehole strainmeter and long-base tiltmeter in Trizonia; install 3 borehole strainmeters. Install the AIG10 multiparameter instrument at 1000 m in depth. Analyze and model the data, correlation with seismicity and other transients.
Innovation/demonstration : Development and test of new tilt and strain high-resolution sensors.
Landslide: contribution to GPS, seismometer, and tiltmeter installation on the Panagopoula landslide, and data analysis; numerical modelling of landslides; repeated kinematic GPS on train.
Tsunamis: provide tide-gage data, install a new tide-gage.

Resources:
instrument arrays of CRL (see Table 1); associated data base; advanced software for data analysis and modeling of geodetic, seismological, and mechanical data.

Publications of IPGP :

Bernard, P., A. Herrero, and C. Berge, Modeling directivity of heterogeneous earthquake ruptures, *Bull. Seismol. Soc. Am. 86,* 1149-1160, 1996.

Bernard, P., P. Briole, B. Meyer, H. Lyon-Caen, et al., The Ms=6.2, June 15, 1995 Aigion earthquake (Greece): evidence for low angle normal faulting in the Corinth rift, *Journal of Seismology 1,* 131-150, 1997.

Bernard, P., P. Pinettes, P.M. Hatzidimitriou, E.M. Scordilis, G. Veis, and P. Milas, From precursors to prediction: A few recent cases from Greece, *Geophys. J. Int., 131,* 467-477, 1997.

Bernard, P., From the search of “precursors” to the research on “crustal transients”, *Tectonophysics,* 338, 225-232, 2001.

Bouchut, F. M.O. Bristeau, A. Mangeney-Castelnau, B. Perthame and J.P. Vilotte, A new model of St Venant and Savage-Hutter for gravity driven shallow water flows, C.R. Acad. Sc. Paris serie I, 336:531-536, 2003

Bouin M.P., Cocco M., Sekiguchi H., G Cultrera and K. Irikura (2000). The rupture process of the MJ=7.2 1995, Kobe earthquake deduced from S-wave polarization analysis. *Geophysical Journal International*, 143, 1-30.
Briole P., Rigo, A., Lyon-Caen, H., Ruegg, J.C., Papazissi, K., Mitsakaki, C., Balodimou, A., Veis, G., Hatzfeld, D. and Deschamps, A., 2000, Active deformation of the Corinth rift, Greece: results from repeated Global Positioning System surveys between 1990 and 1995, *J. Geophys. Res. 105*, 25605-25625.
Favreau, P. and R. Archuleta, Direct seismic energy modeling and application to the 1979 Imperial Valley earthquake, *Geophys. Res. Lett., 30*, 2003.
Favreau, P., M. Campillo and I.R. Ionescu, Initiation of instability under slip dependent friction in the three dimension, *J. Geophys. Res., 107*, 2002.
Mangeney, A., J.-P. Vilotte, M.O. Bristeau, B. Perthame, S. Yemini and C. Simeoni, Numerical modeling of avalanches based on Saint-Venant equation using kinetic scheme, *J. Geophys. Res*., in press, 2003.
Pinettes, P., P. Bernard, P.-A. Blum, R. Verhille, P. Milas, and G. Veis, Strain constraint on the source of the alledged VAN precursor of the 1995 Aigion earthquake (Greece), *J. Geophys. Res. 103*, 15145-15155, 1998.

ENS

skills:
expert in seismology, geodesy, data analysis and modelling

main role:
seismology: standard CRLNET data analysis, data base, CRL Web, advanced data analysis (relocation, multiplets, source studies, fault plane solution analysis); integration of data from various seismic network; contribution to the GPS work

Ressources:
advanced software for data analysis

ENS references:

Calais, E., R. Bayer, J. Chéry, F. Cotton, E. Doerflinger, M. Flouzat, F. Jouanne, M. Kasser, M. Laplanche, D. Maillard, J. Martinod, F. Mathieu, P. Nicolon, J.M. Nocquet, O. Scotti, L. Serrurier, M. Tardy, C. Vigny. REGAL: réseau GPS permanents dans les Alpes occidentales. Configuration et premiers résultats. C. R. Acad.Sci.,331,pp435-442,2000.
Lyon-Caen, H., P. Papadimitriou, A. Deschamps, P. Bernard, K. Makropoulos, F. Pacchiani, G. Patau, First results of CRLN seismic arraay in the western Corinth rift: evidence for old fault reactivation, Compte-Rendu Ac. Sci, in press, 2003.
Tiberi C, Diament M, Lyon-Caen H, King T Moho topography beneath the Corinth Rift area (Greece) from inversion of gravity data, G. J. I., 145, 797-808, 2001
Tiberi C., Lyon-Caen, H., Hatzfeld, D., Achauer, U., Karagianni, E., Kiratzi, A., Louvari, Panagiotopoulos, D. , Kassaras, I., Kaviris, G., Makropoulos, K., Papadimitriou, P., Crustal and upper mantle structure beneath the Corinth rift (Greece) from a teleseismic tomography study, J. Geophys. Res. Vol. 105 , No. B12 , p. 28,159, 2000.
Vigny, C., H. Perfettini, A. Walpersdorf, A. Lemoine, W. Simons, D. Van Looon, . Ambrosius, C. Stevens, R. McCaffrey, P. Morgan, Y. Bock, C. Subarya, P.Manurung, J. Kahar, H. Abidin, S. Abu. Migration of seismicity and earthquake

interactions monitored by GPS in S.E. Asia triple Junction : Sulawesi, Indonesia. Journal of Geophysical Research, 107(B10), 2231, doi:10.1029/2001JB000377, 2002.

Vigny, C., A. Socquet, C. Rangin, N. Chamot-Rooke, M. Pubellier, M.-N. Bouin, G. Bertrand, M. Becker, Present day crustal deformation around Sagaing fault, Myanmar, Journal of Geophysical Research, in press, 2002JB001999, 2003

Zahradnik, J., J. Jansky, E. Sokos, A. Serpetsidaki, H. Lyon-Caen P. Papadimitriou, Modeling the M=4.7 mainshock of the February-July 2001 eathquake sequence in Aegion, Greece, J. of Seismology, in press, 2003.

<u>**CNRS/GeoAzur**</u>

Skill :

Expert in hydromechanics and hydrogeology of subsurface fractured rock masses, strain and pressure coupled measurement and modeling, multi-scalar complex stable/unstable gravitational movements.

Involvment in seismic networks installation and maintenance using telecommunications.

Expert in analysis of seismic signal, location of earthquakes and wave propagation.

Main role :

Landslide: coupled analysis of hydromechanical behavior of the Panagopoula landslide

- bibliographic synthesis
- hydrogeological and hydrochemical measurements
- contribution to instrument installation with IPGP
- high-accuracy tacheometric measurements
- data analysis and 3D modelling

Seismology: CRLNET

- running and upgrade, telemetry
- integration of data from the others partners
- earthquakes characterisation
- velocity model characterisation to improve event location.

Resources :

Tacheometer Leica TDA5005 (with accessories), two high-accuracy pressure/conductivity OTT gauges (with automatic data collecting), 3D flow and hydromechanical numerical models of complex discontinuous media (3FLOW and 3DEC from ITASCA@).

Publications of CNRS/GeoAzur

Bertrand E., Deschamps A., Virieux J.. Crustal structure deduced from receiver functions via single-scattering migration. Geophys. J. Int., 2002, 150, 2, 524-541

Compagnon F., Guglielmi Y., Mudry J. Follacci JH.P., et Ivaldi J.P., 1997, Approche chimique et isotopique de l'origine des eaux en transit dans un grand glissement de terrain : exemple du glissement de la Clapière (Alpes-Maritimes). C.R.Acad.Sci., Paris, 325 (II), pp. 565-570.

Courboulex F., C. Larroque, A. Deschamps, C. Gélis, J. Charreau, J.F. Stéphan (2003) : An unknown active fault revealed by microseismicity in the south-east of France, *Geophys. Res. Lett.* , 30, 15.

Deschamps A., Courboulex F., Gaffet S., Lomax A., Virieaux J., Amato A., Azzara R., Castello B., Chiarabba C., Cimini G.B., Cocco M., Di Bona M., Margheriti L., Mele F., G. Selvaggi, Chiaraluce L., Piccinnini D. and Ripepe D. (2000). Spatio-Temporal evolution of seismic activity during the Umbria-Marche crisis, 1997. Journal of Seismology, 4, N.4, 377-386.

Deschamps A., Courboulex F., Gaffet S., Lomax A., Virieux J., Amato A., Azzara A., Castello B., Chiarabba C., Cimini Gb., Cocco M., Di Bona M., Margheriti L., Mele F., Selvaggi G., Chiaraluce L., Piccinini D., Ripepe, M.. , Spatio-temporal distribution of seismic activity during the Umbria-Marche crisis, 1997. J. Seismology, 2000, 4, 4, 377-386

Guglielmi Y., Bertrand C., Compagnon F, Follacci J.P., and J. Mudry, 2000 – Acquisition of water chemistry in a mobile fissured basement massif : its role in the hydrogeological knowledge of the La Clapiere landslide (Mercantour massif, southern Alps, France). Journal of Hydrology, 229, pp 138 - 148.

Guglielmi Y. et Mudry J., 2001, Quantitative measurement of channel-block hydraulic interactions by experimental saturation of a large, natural, fissured rock mass. Groundwater, Vol.39, N°.5, pp.696-701.

Guglielmi, Y., G. Steve, and E. David - Introducing groundwater geochemistry study in the surveillance of water infiltration effects on large moving rock masses stability : example of La Clapière landslide (France). Geomorphology, in press, 2003

Pedersen Helle, Coutant Olivier, Deschamps Anne, Soulage Michel, Cotte Nathalie. Measuring surface wave phase velocities beneath small broad-band arrays: tests of an improved algorithm and application to French Alps. Geophys. J. Int., 2003, 154, 3, 903-912

IFP, France

Skill

Private industrial research centre, expert in basin modelling, erosion/sedimentation processes, geomechanics.

Main role

IFP will study the evolution of the erosion and subsidence rate during the last Myr (age of the current Gulf). Our 3D numerical approach of the facies distribution allows to predict the deposit versus the subsidence and the sediment inflow. Therefore we may invert the system and deduce these parameters from the sediments distribution. Based on field and subsurface data we will quantify the uplift and subsidence of both onshore and offshore part of the Gulf. Using 3D restoration tools we will define the evolution of the Gulf and its coasts.

Resources

IFP has a permanent team of about 2000 researchers, more than 300 working in earth-sciences (geology, geophysics, reservoirs).

Large laboratory facilities. Numerous exclusive softwares for basin modelling. DYONISOS (3D software for sedimentary models, IFP proprietary), CIN3D (plug-in of GOCAD, a 3D software for restoration, IFP and EDS proprietors).

Marion Dufresne cores in the Gulf of Corinth (stored in the MNHN, IFP Main Scientist)

Large data base on the fault, samples, core samples and data on fault hydraulic behaviour in the Gulf of Corinth.

Publications of IFP

Causse, C., I Moretti, F Ghisetti, R Eschard, L Micarelli, B Ghaleb, N Frank, 2003, Kinematics of the Corinth Gulf inferred from calcite dating and syntectonic sedimentary characteristics, CRAS, In press.

Daniel, J.M., I. Moretti, L. Micarelli, S. Essautier Chuyne & C. Delle Piane, 2003. Faulting in prefractured carbonates: Macroscopic structural analysis of Ag10 Well (Gulf of Corinth, Greece), Submitted to CRAS-Structural Geology/Deformation mechanisms, In press

Le Pourhiet L., Burov E., Moretti I., 2003, Initial crustal thickness geometry controls on the extension in a back arc domain: The case of the Gulf of Corinth. Tectonics, v 22, n 4, 1032-1041.

Micarelli, L., Moretti I., Daniel J.M., 2003. Influence of depth and amount of displacement of the characteristics of normal faults, case study in the Gulf of Corinth – Greece, Journal of Geodynamics. 36, 275-303.

Moretti , I., D. Sakellariou , V. Lykousis, L; Micarelli, 2003. The Gulf of Corinth : a half graben ? Journal of Geodynamics. 36, 323-340.

Moretti, I., V Lykousis, D Sakellariou, J-Y Reynaud, B. Benziane, A Prinzhoffer, 2003. Subsidence rate in the Gulf of Corinth : what we learn from the long piston coring, Submitted to CRAS-Structural Geology/Deformation mechanisms, In press

<u>IRSN</u>

Skill:

expert in seismic hazard assessment, seismology and site effects, data analysis, and modelling for engineering purposes. Expert in paleoseismology, research of recent deformation evidences.

Main role:

Seismology: data base for the CORSSA and RASMON arrays, seismic source studies (stochastic broad band simulation of large earthquakes, empirical attenuation relationships).

Site Effects: strong motion data analysis and modelling. Study of soft soil behavior and non linearity effects.

Paleoseismology: paleoearthquakes identification (trench studies, topography analysis).

Resources:

instrument arrays of CORSSA and RASMON (see Table 1); associated data base; advanced software for data analysis and modeling of seismological data including linear and non linear soil characteristics.

IRSN publication

Berge-Thierry C., Griot-Pommera D., Cotton F., Fukushima F., New empirical response spectral attenuation laws for moderate European earthquakes, Journal of Earth. Eng., Vol. 7, 2003.

Berge-Thierry C., Bernard P., Herrero A., Simulating strong ground motion with the ``k-square " kinematic source model : An application to the seismic hazard in the Erzincan Basin, Turkey, Journal of Seismology, Vol.5, 2001.

Bonilla L.F., Steidl J.H., Gariel J.C., Archuleta R.J., Borehole Response Studies at the Garner Valley Downhole Array: Southern California., Bull. Seism. Soc. Am., Vol. 92, No. 8, PP. 3165-3179, December 2002.

Fukushima Y., Volant P., Berge-Thierry C., Griot-Pommera D.A. and Cotton F., Trial of Developing Attenuation Relation with Near fault saturation terms for Europe, Journal of Earthquake Eng., in press, 2003.

Lemeille F., Sorel D., Bourdillon C., Guernet C., Manakou M. et Berge-Thierry C. , Quantification de la déformation associée à la faille d'Aigion (Golfe de Corinthe, Grèce) par l'étude des dépôts du Pléistocène supérieur et de la transgression marine holocène, Géoscience-Compte rendus de l'Académie des Sciences Paris, 334, 2002.

Pantosti D., De Martini P.M., Papanastasiou D., Lemeille F., Palyvos N. and Stavrakakis G., Paleosismological trenching across the Atalanti Fault (Central Greece): evidence for the ancestors of the 1894 earthquake during Middle Age and Roman time, Bull. Seism. Soc. Am., in press, 2003.

<u>University of Paris 6</u>

Skill:

expert in hydrogeology and geophysics, fluid-earthquake interaction, equipment of wells, signal analysis, and modelling.

Main role :

Equipment of wells: maintain and extend the borehole survey network, with equipment of pressure sensor or flowmeter on new wells, selected by their confined characteristics.
Hydrogeology: Analysis of the hydrogeology regional setting with the identification of different reservoir aquifers, analysis and modelling of hydrogeological signal (pressure or flux).
Signal analysis: characterization of rain, anthropogenic effect, atmospheric pressure and earth tides effect on groundwater to identify the seismic signature on transient fluid, calibrate the well by quantifying the sensitivity of the well to a known deformation (earth tides deformation).
Geophysics: Characterization of seismic spatial deformation using the responses of wells; 3D-modelling of seismic dislocation by finite differences. Measure of interactions between transient fluid and earthquake mechanism in a heterogeneous environment; development of a hydro-mechanical model characterizing the main mechanisms inducing the observed variations of fluid pressure in the superficial crust.

Resources:

Instrument arrays of CRL (see Table 1); associated data base; advanced software for data analysis and modelling of hydrogeology and seismic dislocation.

Publications of University Paris 6

Flotté N., Plagnes V., Sorel D., Benedicto A., (2001) - U/Th and stratigraphic dating of a quaternary fault's death. The Xylokastro-Loutro fault, northern Peloponnesus, Greece. Geophysical Research Letters, 28 (19), 3769-3772.

Gavrilenko,P., G. Melikadze, T. Chelidze, D. Gibert, and G. Kumsiashvili (2000). Permanent water level drop associated with the Spitak earthquake: observations at Lisi Borehole (Republic of Georgia) and modelling, Geophys. J. Int., 143, 83-98

Leonardi, V., Arthaud, F., Tovmassian, A. and Karakhanian, A.S. (1998) - Tectonic and seismic conditions for changes in spring discharge along the Garni right lateral strike slip fault (Armenian Upland). Geodinamica Acta, vol.11, n°2-3, 85-103.
Leonardi V., Arthaud F., Tovmassian A. & Karakhanian A.S. (1997) - Relationships between seismic activity and piezometric level changes ine the Arax basin (SW Armenia). Attempt to a typology of seismically induced piezometric anomalies. Tectonophysics, 273, 293-316.
Pinault J-L, Plagnes V., Aquilina L., Bakalowicz M. (2001) - Inverse modeling of the hydrological and the hydrochemical behavior of hydrosystems - Characterization of karst system functioning. Water Resources Research, 37 (8), 2191-2204.

UPATRAS

Skill:
Expert in seismology, geophysics, instrumentation and data transmission via radio and satellite communications.

Main role:
Seismology: Installation of 2 BB borehole seismometers and online connection via satellite to Patras Seismological Centre. Contribution of 2 PATNET stations. Provide the means for satellite transmission of one borehole strainmeter to Patras Seismological Centre. Construction of 2 vaults for the BB stations of CUP.
Tsunamis: Install of radio-link of tide gage data to Patras Seismological Centre.
Innovative/demonstration: Further development and test of a new sensor to monitor landslides based on optical fibre and Acoustic Emission.

***Resources*:**
Operate since 1992 a permanent microearthquake network (PATNET) in the region of W. Greece transmitting data via radiolink; Operating since 2002 a BB network based on Satellite transmission; various geophysical equipment, 240 channel seismic unit, 2 Vibroseis, 120 portable seismographs, advanced software for seismological and geophysical data processing.

Publicatios of Upatras:
Tselentis G-A 1997: *Evidence of Q stability during the Egion Jun 15 1995 earthquake sequence*. Bull. Seismol. Soc. America, 87,6, 1679-1684.
Tselentis G-A.. Melis N.S., Sokos E. And Papatsimpa K. 1996: *The Egion June 15, 1995 (6.2 ML.) earthquake, W. Greece*. PAGEOPH,147, pp.83-98.
Tselentis G-A., 1998: *Intrinsic and scattering attenuation in W. Greece*. PAGEOPH, 153, 703-712Tselentis G-A, and Delis G., (1999): *Rapid assessment of S-wave profiles from the inversion of multichannel surface wave dispersion data*. Annali di Geofisica, 41,1, 1-17.
Tselentis G-A and Zahradnik J., 2000: *The Athens earthquake of 7 September 1999*. Bull. Seism. Soc. Am., 90,5, 1143-1160.
Burton, P. W., Xu, Y., Tselentis, G-A., Sokos, E., & Aspinall, W., (2003): Strong Ground acceleration seismic hazard in Greece. Soil Dynamics & Earthquake Engineering 23,159-181

NKUA

Skill:
Expert in seismology and geophysics for instrumentation, data analysis, and modelling

Main role:
Seismology: maintain the RASMON and CORSSA accelerometric arrays as well as 3 stations of the ATHENET seismological network equipped with BB seismometers which will be installed in near-surface boreholes (2-3 meters depth). Data of the latter will be transmitted in real time, via dedicated data lines. Database creation and continuous feeding for RASMON and CORSSA networks, as well as for selected stations of ATHENET network. Data processing in close collaboration with the other partners and data analysis including standard and non standard determination of location, moment magnitude determination, focal mechanisms, doublet analysis, relocation and stress analysis. Analysis of seismological data in space-time characterization and interpretation of seismicity. Analysis and modeling of seismic wave propagation from 1000m to the surface using CORSSA data.
Offshore slope failure and tsunamis: Monitoring of HF acoustic waves for slump and transients.

Resources:
Instruments of RASMON, CORSSA and ATHENET arrays, accelerographs from the SL's pool, associated data bases, advanced software for data analysis and modelling of seismological data

Publications of NKUA

Makropoulos , K., and Burton, P.W., 1985. Seismic hazard in Greece: II ground acceleration. Tectonophysics, 117, 259-294.

Makropoulos, K., Drakopoulos, J., Latousakis, J., 1989. A revised and extented earthquake cataloque for Greece since 1900. Geophys. J. Int., 98, 391-394

Makropoulos, K., Diagourtas, D., Voulgaris, N., Drakopoulos, J., 1996. A study of Site Effects on Strong Motion Records Obtained from Local Network Around Gulf of Corinth, (Central Greece), 1996. In V. Schenk (ed), Earthquake Hazard and Risk, 241-252, Kluwer Academic Publishers

Haslinger, H., Kissling, E., Ansorge, J., Hatzfeld, D., Papadimitriou, E., Karakostas, V., Makropoulos, K., Kahle, H.-G., and Peter, Y., 1998. 3D Crustal Structure from Local Earthquake Tomography Around the Gulf of Arta (Ionian region, NW Greece). Tectonophysics, 304, 201-218

Slejko, D., Camassi, R., …, Makropoulos, K.,…, and P. Zupancic, 1999," Seismic hazard assessment for Adria" . Ann. di Geofisica V.42 No. 6, 1085-1107.

Papadimitriou P., Kaviris G., and Makropoulos K., 1999. Evidence of shear wave splitting in the eastern Corinthian Gulf (Greece), Physics of the Earth and Planetary Interiors, 114, 3-13.

Hatzfeld, D., Karakostas, V., Ziazia, M., Kassaras, I., Papadimitriou, E., Makropoulos, K.C., Voulgaris, N. and Paopaioannou, C. 2000. Microseismicity and faulting geometry in the Gulf of Corinth (Greece). Geophys. J. Int. 141, 438-456.

Diagourtas, D., Tzanis, A., and Makropoulos, K., 2001. Comparative study of microtremor analysis methods. Pure Appl. Geophysics, 158, 2463-2479.

Papadimitriou P., Voulgaris N., Kassaras I., Kaviris G., Delibasis N., and Makropoulos K., 2002. The Mw=6.0 7 September 1999 Athens Earthquake, Natural Hazards, 27, 15-33.

HCMR

Skill:
expert in marine geology – geophysics, sequence stratigraphy, slope stability/landslides, sea level changes.

Main role:
Marine geology-geophysics: high-resolution seismic and swath bathymetric investigation of active and potential submarine sliding sites and of recent offshore fault rupture, estimation of fault-slip rates.
sequence stratigraphy: Gravity coring and sequence stratigraphic interpretation of the sedimentary infill.
slope stability/ offshore landslides: down-core measurement of geotechnical properties, estimation of slope stability.
sea level changes: identification of submarine terraces, relation with onshore marine terraces, estimation of subsidence versus uplift rates.
Tsunamis: provide location of potential tsunamigenic sites and geometrical characteristics of sliding masses

Resources:
R/V AEGAEO, Remote Operated Vehicle 'Achilles', geophysical equipment, coring equipment, laboratory facilities for geotechnical measurements (Multi Sensor Core Logger)

Publications of HCMR

Lykousis V. and Chronis G., 1989. Mass Movements, Geotechnical properties and slope stability in the Outer Shelf Upper Slope, N.W. Aegean Sea. Marine Geotechnology, 8 (3): 231-247.

Lykousis V., 1991. Submarine slope instabilities in the Hellenic Arc region, Northeastern Mediterranean Sea. Marine Geotechnology, 10: 83-96.

Lykousis V., Chronis G. and Ferentinos G., 1994. Prodelta sediment gravity processes in seismotectonically active area: W. Korinthiakos Gulf, W. Greece. Proc. 15th Reg. Meeting Internat. Assoc. of Sedimentologists: 258-259.

Lykousis V., Chronis G. and Rousakis G., 1994. Submarine prodelta instabilities in the seismotectonic active shelf off W. Greece. In: R.Oliveira, et al. (Eds) Proc. 7th Congress International Association of Engineering Geology. Lisbon, , Balkema Publ., Rotterdam, V.III : 1549-1555.

Lykousis V., Papanikolaou D. & Sakellariou D., 1997. Geodynamically induced catastrophies of coastal ancient cities in Egialia, W. Korinthiakos Gulf, Greece. In: Marinos et al.(eds) "Engineering. Geology & Environment", V.3: 3197-3202, Balkema Pupl. Co. Amsterdam.

Lykousis V., Sakellariou D. and Papanikolaou D., 1998. Sequence stratigraphy in the northern margin of the Gulf of Corinth: Implications to Upper Quaternary basin evolution. Bull. Geol. Soc. Greece, 32/2 : 157-165

Lykousis V, Rousakis G, Alexandri M , Pavlakis P and Papoulia I, 2002. Sliding and regional slope stability in active margins: North Aegean Trough (Mediterranean). Marine Geology, 186: 281-298.

Lykousis V, Sakellariou, D. and Rousakis G., 2003. Prodelta slope stability and associated coastal hazards in tectonically active margins: Gulf of Corinth (NE

Mediterranean).In: J. Locat and J. Mienert (eds) Submarine Mass Movements and their Consequences pp. 433-440.
Moretti, I., Sakellariou, D., Lykousis, V. and Micarelli, L., 2003. The Gulf of Corinth: an active half graben? Journal of Geodynamics, 36: 323-340.
Perissoratis, C., Piper, D.J.W.and Lykousis, V., 2000. Alternating marine and lacustrine sedimentation during late Quaternary in the Gulf of Corinth rift basin, central Greece. Marine Geology, 167 : 391-411.

NOA

Skill
The National Observatory of Athens is the oldest research center of Greece consisting of five institutes. One of them, the Institute of Geodynamics (NOAGI), has been responsible for the 24-hour monitoring of the country by means of its national seismograph network. NOAGI has accumulated through the years a big amount of observational data, scientific experience and technical expertise in seismic monitoring , earthquake research , geophysics and volcanology.
The Institute of Space Applications & Remote Sensing (ISARS) specializes in Space Physics, Remote Sensing, Ionosperic Physics and Telecommunications. Expert in remote sensing, signal processing and pattern recognition development algorithms. Processing of SAR data. Production and analysis of differential interferograms based on ERS SAR imagery.

Main role
tsunamis: NOA/GI will investigate paleotsunami events in the Corinth Gulf on the basis of historical documentation and field geological observations
geodesy: NOA/ISARS will be study: Long term reception and pre-processing of a large volume of SAR imagery over the target area; InSAR processing, cleaning and enhancement of interferometric processing results; production of PSs maps to monitor the surface deformation field over a long time frame; modelling of the observed deformation field.

Resources:
Advanced image processing laboratory and specialized SW tools for data analysis and interferometric processing.

Publications of NOA:
Dominey-Howes, D.T.M., G.A. Papadopoulos and A.G. Dawson Geological and historical investigation of the 1650 Mt. Columbo (Thera Island) eruption and tsunami, Aegean Sea, Greece. *Natural Hazards,* 21, 83-96, 2000.
Kontoes C.C., Elias P., Sykioti O., Briole P., Remy D., Sachpazi M., Veis G., Kotsis I., "Displacement field mapping and fault modeling of the September 7th, 1999 Athens earthquake based on ERS-2 satellite radar interferometry", Geophysical Research Letters, Vol. 27, No 24, pp. 3989-3992 (2000GL008510), 2000.
Minoura, K., F. Imamoura, U. Kuran, T. Nakamura, G.A. Papadopoulos, T. Takahashi and A.C. Yalciner Discovery of Minoan tsunami deposits. *Geology,* 28, 1, 59-62, 2000.
Papadopoulos, G.A., and Th. Dermentzopoulos A tsunami risk management pilot study in Heraklion, Crete. *Natural Hazards*, 18, 91-118, 1998.

Perissoratis, C., and G. Papadopoulos Sediment instability and slumping in the southern Aegean Sea and the case history of the 1956 tsunami. *Marine Geology*, 161, 287-305, 1999.

Papadopoulos, G.A., Tsunami hazard in the Eastern Mediterranean : strong earthquakes and tsunamis in the Corinth Gulf, Central Greece . *Natural Hazards,* 29, 437-464, 2003.

Sachpazi M., Kontoes C.C., Voulgaris N., Laigle M., Vougioukalakis G., Sikioti O., Stavrakakis G., Baskoutas J., Kalogeras J., Lepine J. Cl., , “Seismological and SAR signature of unrest at Nisyros caldera, Greece”, Journal of Volcanology and Geothermal Research, ELSEVIER, Vol. 116, pp. 19-33., 2002.

Sykioti O., Kontoes C.C., Elias P., Briole P., Sachpazi M., Paradisis D., Kotsis I., “Ground deformation at Nisyros volcano (Greece) detected by ERS-2 SAR differential interferometry”, International Journal of Remote Sensing, Vol. 23, No 1, pp. 183-188, 2003.

AUTH

Skill:

Expert in Earthquake Engineering, Lifeline earthquake engineering, Seismic vulnerability assessment and protection of structures, Engineering Seismology, Soil Dynamics, Microzonation studies of many important cities in Greece and Cyprus etc. Laboratory services quality certified by ISO9001.

Main role:

Study the effects of surface geology on ground motion, non-linear phenomena, soil behaviour and liquefaction phenomena.

Resources:

Accelerographs and pore pressure sensors, seismometers, advanced geophysical equipment, advanced software for data analysis and modelling of geotechnical – geophysical data. Laboratory, with a current value of 2 million euro, covers an area of $700m^2$, including laboratories and office space.

Publications of AUTH

Chavez-Garcia F., Raptakis D., Makra K., Pitilakis K. ‘Site Effects at Euroseistest II. Results form 2D numerical modelling and comparison with observations’, *Soil Dynamics and Earthquake Engineering*, (2000) Vol. 19, 23 - 39

Pitilakis K., ‘Site Effects’, Chapter 5 in The Century of Space Science, Kluwer Academic Publishers, 2003, pp. 139 – 189

Pitilakis K., Makropoulos K., Bernard P., Lemeille F., Berge-Thierry C., Tika Th., Manakou M., Diagourtas D., Raptakis D., Kallioglou P., Makra K. Pitilakis D. Bonilla L.F., ‘The Corinth Gulf Soft Soil Array (CORSSA) to study Site Effects’, *(accepted for publication in Comptes Rendus)*

Raptakis D., Chavez-Garcia F., Makra K., Pitilakis K. ‘Site Effects at Euroseistest I. Determination of the valley structure and confrontation of observations with 1D analysis’, *Soil Dynamics and Earthquake Engineering,* (2000) Vol. 19, 1 – 22

Chavez-Garcia F., Raptakis D., Makra K., Pitilakis K. ‘Site Effects at Euroseistest II. Results form 2D numerical modelling and comparison with observations’, *Soil Dynamics and Earthquake Engineering*, (2000) Vol. 19, 23 - 39

Sextos, A.; Pitilakis, K and A. Kappos 'Inelastic dynamic analysis of RC bridges accounting for spatial variability of ground motion, site effects and soil-structure interaction phenomena. Part 1: Methodology and Analytical tools', *Earthquake Engineering and Structural Dynamics*, (2003) Vol. 32(4), 607-627

Sextos, A.; Kappos, A. and K. Pitilakis 'Inelastic dynamic analysis of RC bridges accounting for spatial variability of ground motion, site effects and soil-structure interaction phenomena. Part 2: Parametric Analysis', *Earthquake Engineering and Structural Dynamics*, (2003) Vol. 32(4), 629-652

Apostolidis P., Raptakis D., Roumelioti Z., Pitilakis K., 'Determination of S -Wave Velocity Structure using MICROTREMORS and Spac method applied in Thessaloniki (Greece)', *(accepted for publication in Soil Dynamics* and Earthquake Engineering)

INGV

Skill:

expert in seismology, tectonics, paleoseismolgy, and fluid geochemistry, remote instrumentation, field surveys, data analysis and modelling.

Main role

Seismology: numerical modelling of fault Interaction and dynamic propagation, 3D-modeling of the fault system, review of historical macroseismic data.

Tectonics: Mapping of the main active faults, mapping and dating of the major uplifted marine terraces and paleoseismology for fault slip rates, kinematics and seismic history.

Transients: Managing the existing GMS/ multi-probe stations of CRL; extend the definition of the geochemical and hydrogeological background to the west; analysis and data modelling, correlation between seismicity and geochemical/hydrogeological transients

Innovation/demonstration: Development and test of new sensors in the geochemical GMS permanent station.

Tsunamis: Recognition and dating of paleotsunami by means of shallow coring and historical records

Resources:

2 permanent GMS station for geochemistry, Geochemical laboratory and field instruments, field instrumentation for microtopography (DGPS and total station), handcoring, and tectonic survey; geochemistry and tectonics data base; advanced software for data analysis and modeling of topographic, seismological, mechanical and geochemistry data.

Publications of INGV

Belardinelli M. E., Bizzarri A., Cocco M. (2003) : Earthquake triggering by static and dynamic stress changes, J. Geophys. Res., 108, No. B3, 2135, ESE 1-1 – 1-16

Bizzarri A., M. Cocco, J. Andrews and E. Boschi (2001). Solving Dynamic Rupture Problem with Different Numerical Approaches and Constitutive Laws, Geophysical Journal International, 144, 656-678.

Cocco M. and J.R. Rice (2002). Pore Pressure and poro-elasticity effects in Coulomb stress analysis of earthquake interactions, J. Geophys. Res., 107, No. B2, 10,1029/2000JB000138.

De Martini, P. M., P. Burrato, D. Pantosti, A. Maramai, L. Graziani and H. Abramson (2002): Identification of liquefaction features and tsunami deposits in the Gargano area (Italy): a geologic contribution to the hazard assessment. *Annali di Geofisica* special issue Ten Years of Paleoseismology in the ILP: Progress and Prospects, in press.

De Martini P.M., D. Pantosti, N. Palyvos, F. Lemeille, L. McNeill, R. Collier (2003): Slip rates of the Aigion and Eliki faults from uplifted marine terraces, Corinth Gulf, Greece, *Geosciences*, in review

Gardi A., Cocco M., A Negredo, R Sabadini and S K Singh (2000). Dynamic Modeling of the subduction zone of Central Mexico. Geophysical Journal International, 143, 809-820.

King G.C.P. and M. Cocco (2001). Fault Interaction By Elastic Stress Changes: New Clues From Earthquake Sequences. Advance in Geophysics Vol. 44, Academic Press, R. Dmowska and B. Saltzman Editors, pp.1-38.

Pantosti D., De Martini P.M., Papanastasiou D., Lemeille F., Palyvos N. and Stavrakakis G., Paleosismological trenching across the Atalanti Fault (Central Greece): evidence for the ancestors of the 1894 earthquake during Middle Age and Roman time, Bull. Seism. Soc. Am., in press, 2003.

Pizzino L., Galli G., Mancini C., Quattrocchi F., Scarlato P. (2002). Natural Gases Hazard (CO_2, ^{222}Rn) within a quiescent volcanic region and its relations with seismotectonics: the case of the Ciampino-Marino area (Colli Albani volcano, Rome). Natural Hazard, 27, 257-287.

Pizzino L., Quattrocchi F., Cinti D., Galli G.. (2003). Fluid Geochemistry along the Eliki and Aigion seismogenic segments (Gulf of Corinth, Greece). C. R. Acad.Sci.Paris, Sciences de la Terre et des Planètes, in Press, 2003.

Quattrocchi F., Favara R., Capasso G., Pizzino L., Bencini R., Cinti D., Galli G., Grassa F., Francofonte S., Volpicielli G. (2003). Thermal Anomalies and fluid geochemistry framework in occurrence of the 2000-2001 Nizza-Monferrato seismic sequence (Northern Italy): episodic changes in the fault zone heat flow or chemical mixing phenomena? Natural Hazard and Earth System Sciences, 3, 269-277.

Quattrocchi F., Di Stefano G., Pizzino L., Pongetti F., Romeo G., Scarlato P., Sciacca U., Urbini G. (2000). The Geochemical Monitoring System (GMS II) prototype installed at the Acqua Difesa well (Belpasso, CT) in the Etna region, addressed to seismic and volcanic surveillance: first data during the volcanic-seismic crisis. J.Volc.Geoth. Res., 101, 273-306.

DFUNIBO

Skill:
expert in tsunami generation and propagation, and tsunami modeling, in seismology and marine geophysics

Main role:
Tsunamis: analysis of tide-gauge records, analysis of historical and instrumental tsunamis, scenarios of tsunamis induced by earthquakes, scenarios of tsunamis induced by landslides, impact in the port of Aigion city.

Resources:

advanced software for modeling landslide motion, and generation and propagation of tsunami

Publications of DFUNIBO

Altinok Y., Tinti S., Alpar B., Ersoy S., Yalçiner A.C., Bortolucci E., Armigliato A., 2001, The tsunami of August 17, 1999 in the Izmit Bay; Turkey, Natural Hazards, **24**, 133-146.

Piatanesi A., Tinti S., 2002, Numerical modeling of the September 8, 1905 Calabrian (southern Italy) tsunami, *Geophys. Jour.Int.*, **150**, 271-284.

Tinti S., Bortolucci E., Chiavettieri C., 2001. Tsunami excitation by submarine slides in shallow-water approximation, *Pure Applied Geophysics*, **158**, 759-797.

Tinti S., Armigliato A., 2003, The use of scenarios to evaluate tsunami impact in South Italy, Marine Geology, **199**, 221-243.

Tinti S., Pagnoni G., Zaniboni F., Bortolucci E., 2003, Tsunami generation in Stromboli and impact on the south-east Tyrrhenian coasts, *Natural Hazards and Earth System Sciences*, **3**, 299-309.

Tinti S., Pagnoni G., Piatanesi A., 2003, Simulation of tsunamis induced by volcanic activity in the gulf of Naples (Italy), *Natural Hazards and Earth System Sciences*, **3**, 311-320.

WAPMERR

Skill

Expert in earthquake and volcanic research and risk assessment. WAPMERR was created for forecasting possible consequences of natural and anthropogenic catastrophes, developing response scenarios, as well as assessment and mitigation of natural and anthropogenic risks. WAPMERR is a non-profit organization with headquarters in Geneva, and branch offices in Moscow (Russia) and Dubai (UAE). Collaboration with the following research groups: Federal Institute of Technology, Zuerich, Switzerland; Geoforschungszentrum, Potsdam, Germany; University of Alaska Fairbanks, USA; University of Southern California, USA; University of California, Los Angeles, USA; University of California, Berkeley, USA; Universidad Nacional de Mexico, Juriquilla, Mexico; Russian Academy of Sciences, Moscow, Russia; Icelandic Meteorological Office, Reykjavik, Iceland; University Kiel, Germany; Tohoku University, Sendai, Japan.

Main role

Catalogues of local earthquakes will be studied to define a sub-set appropriate for time, space and magnitude studies.

Seismicity rate changes, as well as other seismicity parameters, will be mapped in correlation with other transients.

Resources

WAPMERR is upgrading its world database on building stock, population distribution, and topography as well as to develop improved methods to calculate scenario, and real time earthquake risk estimates, and flooding scenarios.

References of WAPMERR

Sammis, C., M. Wyss, B. Nadeau and S. Wiemer, Comparison Between Seismicity on Creeping and Locked Patches of the San Andreas Fault Near Parkfield, CA: Fractal Dimension and b-value Bull. Seism. Soc. Amer., in press, 2003.

Sanchez, J. J., S. R. McNutt, J. A. Power, and M. Wyss, Spatial variations in the frequency-magnitude distribution of earthquakes at Mount Pinatubo volcano Bull. Seism. Soc. Am., in press, 2003.

Sanchez, J.J, M. Wyss and S. R. McNutt, Temporal-spatial variations of stress at Redoubt volcano, Alaska, inferred from inversion of fault plane solutions J. Volcan. Geotherm., in press, 2003

Westerhaus, M., M. Wyss, R. Yilmaz, and J. Zschau, Correlating variations of b values and crustal deformations during the 1990s may have pinpointed the rupture initiation of the Mw=7.4 Izmit earthquake of 1999 August 17 Geophysical Journal International, 148, 139-152, 2002.

Wiemer, S., and M. Wyss, Spatial and temporal variability of the b-value in seismogenic volumes: An overview Advances in Geophysics, 45, 259-302, 2002.

Wyss, M., A. Hasegawa and J. Nakajima, The source and path of magma for volcanoes in the subuction zone of northeastern Japan Geophys. Res. Letts., 28, 1819-1822, 2001.

Wyss, M., Locked and Creeping Patches Along the Hayward Fault, California Geophys. Res. Letts., 28, 3537-3540, 2001.

Wyss, M., and S. Matsumura, Most likely locations of large earthquakes in the Kanto area, Japan, estimated based on local recurrence time Phys. Earth Planet. Interiors, 131, 173-184, 2002.

Zuniga, R.F., and M. Wyss, Most and least likely locations of large to great earthquakes along the Pacific coast of Mexico, estimated from local recurrence times based on b-values Bull. Seism. Soc. Amer., 91, 1717-1728, 2001.

University College Dublin

Skill:

Expert in numerical modelling of fluid flow, seismic wave propagation and coupled fluid-wave-solid interactions, in heterogeneous media, using discrete mechanics

Main role:

Seismology data analysis Analysis of multiplets for temporal variations in micro-mechanical damage, following transients.

Hydro-mechanical: Numerical modelling of hydro-mechanical coupling using schemes based on discrete mechanics.

Resources:

In-house software for modelling wave fluid-wave-rock interactions, including chemical feedbacks. Advanced software for data analysis. Parallel Beowulf clusters.

Publications of UCD

Marsan , D and Bean C.J.. Multifractal modeling and analysis of crustal heterogeneity. 207-233. In Heterogeneity in the crust and upper mantle, eds J Goff and K. Holliger, Kluwer Academic, 2003

O Brien G Bean C.J. and McDermott F. A comparison of published experimental data with a coupled lattice Boltzmann-analytic advection-diffusion method for reactive transport in porous media, *Journal of Hydrology*, 268, 143-157, 2002.

O' Brien, G.S. Bean C.J. and McDermott F. Numerical investigations of passive and reactive flow through generic single fractures with heterogeneous permeability. Earth and Planetary Science Letters, 213, 271-284, 2003

O' Brien, G.S. Bean C.J. and McDermott F. A numerical study of transport through fault zones. Earth and Planetary Science Letters, 214, 633-643, 2003

Toomey A and Bean C.J. Numerical simulation of seismic waves using a discrete particle scheme. *Geophys J. International,* 141, 595-604, 2000

Toomey A and Bean C.J and Scotti O. Fracture properties from seismic data – a numerical investigation. *Geophysical Research Letters*, 29 (4) art no 1050, 2002

Charles University Prague

Skill:
mathematical methods in geophysics (global geodynamics, oil exploration, earthquake seismology), 3D finite-difference and hybrid numerical modeling, numerous studies on seismic source-path-site effects, observation and modeling of earthquakes in Greece since 1998.

Main role:
Seismology: data base for the broad-band and strong-motion seismic stations Sergoula and Mamousia; software development and application of multiple-source inversion; New installation of existing broad-band instruments in vaults to provide thermal protection and improve detection of weak events possibly accompanying strain signals measured by other CRL groups; development of new methods and software for non-standard seismic source inversion based on synthetic and empirical Green functions.

Resources:
broad-band and strong-motion instruments (see Table 1); continuously updated original software for seismic wave propagation, source inversion and strong-motion simulation .

Selected Publications of CUP:

Caserta, A., Zahradnik, J., Plicka, V., 1999. Ground motion modelling with a stochastically perturbed excitation. *J. Seismology, 3,* 45-59.

Novotny, O., Zahradnik, J., and Tselentis, G-A., 2001. North-western Turkey earthquakes and the crustal structure inferred from surface waves observed in the Corinth Gulf, Greece. *Bull. Seism. Soc. Am. 91*, 875-879.

Oprsal, I., Zahradnik, J., 2002, 3D finite-difference method and hybrid modeling of earthquake ground motion, *J. Geophys. Res., 107*(B8), 10.1029/2000JB000082, 2002

Plicka, V., Zahradnik, J., 1998. Inverting seismograms of weak events for empirical Green's tensor derivatives. *Geophys. J. Int., 132*, 471-478.

Riepl, J., Zahradník, J., Plicka, V., Bard, P.-Y., 2000. About the efficiency of numerical 1D and 2D modeling of site effects in basin structures. *Pure and Appl. Geophys., 157,* No. 3, 319-342.

Tselentis, G.-A., Zahradnik, J., 2000. The Athens earthquake of September 7, 1999. *Bull. Seism. Soc. Am. 90,* No. 5, 1143-1160.

Zahradnik, J., Jansky, J., Papatsimpa, N., 2001. Focal mechanisms of weak earthquakes from amplitude spectra and polarities . *Pure and Appl. Geophys., 158*, 647-665.

NEURON

Skill :

Neuron SA offers and develops integrated products and services for satellite and terrestrial Communications, networking and web solutions. Having high standard technostructure and highly skilled human resources with important expertise in real-time acquisition and alert systems. Based on key alliances as well as strategic agreements with world-leader companies in the fields of Telecommunications and Networking such as LMGT Group (Locheed Martin Global Telecommunications), Viasat (USA), Comsat (USA), Raytheon Group (USA-Raylink), Access Media (IT), Netdish (IT), Neuron SA mission is to create and be the leader in hybrid solutions market by offering the following:

- Integration services combining satcom, wireless (WiFi), internet technologies and software development, aiming at the optimization of applications and achieving high quality turn key solutions.
- Innovative business models and applications.
- 24x7 support provided through Service Level Agreements (SLA)

Main role:
Neuron’s contribution will be focused on CRL information systems, real-time acquisition and alarm systems for seismic, landslide and tsunami hazard monitoring, web-based software development. Neuron will be in contact with all possible end-users in order to identify their needs and establish the system requirements.

Resources:
Neuron SA utilizes advanced software design, development, simulation and implementation tools, taking full advantage of widely used technology (client/server, legacy systems) as well as key technological advances (multi-tier architecture, web-enabled applications, Java, etc.). In order to perform 24x7 support, Neuron runs a high technology Network Operations Center equipped with servers running Unix, Linux, MS Windows NT/2000, large UPS, power generator, LMDS link for high speed internet access and lately Neuron became the first Greek company that bought satellite segment from the first Greek satellite HELLAS-SAT II.

Software Development Tools and Technologies
Oracle Developer/Discoverer/Designer, MS Visual Studio, Oracle RDBMS (v.7, v.8, v.9), Progress 4GL/RDBMS v.8, Distributed object technologies CORBA and RMI, Mobile agent technologies (Grasshopper Agent Platform), Web programming (Servlets, Applets, EJB), Web Services and Protocols (SOAP, WSDL, UDDI), Embedded platforms (J2ME, Personal Java), Relational Databases Programming (JDBC, SQL Server 2000), Markup Languages: HTML, XML

OPGC

Skill

The EM team of OPGC is working on electromagnetic phenomena related to volcanic and seismic activity since more than 20 years: monitoring in magnetism and electricity, electromagnetic tomography. Experience in rock magnetism and in laboratory experiments. In charge of ground-based electromagnetic stations in Demeter program launched by the CNES. The team can built its own equipment, set it on the field, elaborate data acquisition softwares, implement radio and internet transmissions, make routinely data processing and work on the mechanisms able to generate the observed EM signals correlated with the tectonic activity. It installed 65 EM continuously recording stations worldwide.

Main role

- Characterization of the first kilometers of the geological structure in the Trizonia island where many instruments are concentrated (IPGP and GFZ strainmeters, tiltmeters, short period and BB seismometer, continuous GPS), by mean of audio-magnetotelluric and magnetotelluric soundings (two parallel lines will be investigated).
- Analysis of the records from the DEMETER/ground segment, electromagnetic station of Trizonia, to be installed in 2004; identification of superficial sources generating potential electromagnetic signals related to seismic activity.

Resources

proton and vectorial magnetometers, electric and SP stations, induction magnetic coils, resistivity-meters.

Publications of OPGC

J. Zlotnicki, V. Kossobokov, and J.L. Le Mouël, 2001. Variation of frequency content of electromagnetic field at the approach and after the 21 July 1995, M=5.7, Yong Deng (China) earthquake. *Tectonophysic, 334, 259-270.*

J. Zlotnicki, J.L. Le Mouël, Y. Sasai, P. Yvetot, and M.H. Ardisson, 2001. Self-Potential changes associated with the volcanic activity. Short-term signals associated with March, 9, 1998 eruption. *Annali di Geofisica, 44, 2, 335-354.*

G. Vargemezis, J. Zlotnicki, and G. Tsokas, 2001. Energy and Polarity of the Telluric field in correlation with seismic activity in Greece. *Annali di Geofisia, 44,2, 205-220.*

M. Mlynarski and J. Zlotnicki, 2001. Fluid circulation in the active emerged Asal rift (East Africa, Djibouti) inferred by Self-Potential and Telluric prospecting. *Tectonophysics, 339, 455-472.*

J. Zlotnicki, Y. Sasai, P. Yvetot, Y. Nishida, M. Uyeshima, F. Fauquet, H.Utada, Y. Takahashi, and G. Donnadieu, 2003. Resistivity and Self-Potential changes associated with volcanic activity : The July 8, 2000 Miyake-jima eruption (Japan), Earth Planet. Sci. Lett., 205, 3-4, 139-154.

J. Zlotnicki and Y. Nishida, 2003. Review on morphological insights of Self-Potential anomalies on volcanoes, in press, Surveys in Geophysics.

B4.2 Main instrumental and data base resources

Institution	Permanent monitoring Equipment in operation, and related data base	New equipment planned	Data availability
IPGP	**CORSTRAIN**: **start oct. . 2002** One borehole strainmeter , depth 150 m , res.10^{-10} One long base hydrostatic tiltmeter, res 10^{-9} **AIG10 borehole**: **since sept. 2003** Pressometer 1 km deep, strain res10^{-10} One hydrophone **Tide-gages: since 1999** 2 tide-gages, res. 0.5 cm **Radon probes: start 1997** 9 radon probes in soil on fault scarp	**CORSTRAIN, year 2** 2 borehole strainmeters, depth 70m, res 10^{-9} 1 borehole strainmeter, depth 100 m, res. 10^{-10} **AIG10 borehole, year 1** installation of existing borehole multisensor instrument (seismometers, tiltmeters, accelerometers, temperature), 1 km depth **Kinematic GPS, year 2** 1 continuous GPS on train, Athens-Patras line	Experimental phase; CRL access to records through collaboration
IPGP	**GPS: start oct. 2002** 5 telemetered continuous GPS	**GPS, year 1** 2 telemetered continuous GPS 2 tide-gages	Immediate Public access
IPGP ENS GeoAzur	**CRLNET: Start 2000** 12 short period seismic stations, local recording 1 broad band STS2 seismometer in vault (sept 2003)	**CRLNET, year 1** Telemetry of 4 stations, including the STS2 broad-band seismometer	Public access to catalogue and data - STS2 real-time access through ORFEUS
UP6	**Groundwater monitoring: Start jan 2002?**: 2 rain gates 2 pore pressure in confined aquifer, strain res 10^{-8}	**Groundwater monitoring, year 1** 1 pore pressure in confined aquifer	Experimental phase; CRL access to records through collaboration
OMP		**H2 monitoring of fault scarp, year 1**	Experimental phase; CRL access to records through collaboration
INGV	**GMS/multipar. probe**, **started oct. 2001** 2 geochemical monitoring systems in artesian wells		Experimental phase; CRL access to records through collaboration
NKUA	**CORNET, start 1996** telemetered seismic array Presently 2 short-period stations in the target area	**ATHNET, year 1** Radio/satellite telemetry of 3 stations near the target area	Public access to catalogue. Access to records through collaboration
NKUA IRSN	**RASMON, start 1994** presently 9 surface accelerometers	**RASMON, year 2** **2 accelerometers**	Public access to catalogue. Access to records through collaboration
NKUA IRSN AUTH	**CORSSA, start 2003** 4 borehole accelerometers in soft soil (0-180 m) 1 reference (soft soil) surface accelerometer 2 pore pressure transducers in boreholes	**CORSSA, year 1** 1 reference (rock site) surface accelerometer 1 borehole (25 m) for pore pressure probe	Public access to catalogue. Access to records through collaboration
UPatras	**PATNET start 1992** **SATNET start 200é** Telemetered seismic array	**SATNET, month 8:** 2 very-broad band, borehole seismometer (20 m and 70 m) with satellite telemetry	Public access to catalogue; access to records through collaboration
CUP	**BB and SM seismometers, start 1998** 2 surface broad band seismometers and 2 strong motion accelerographs	**BB seismometers, year 1** New installation in underground vaults	free access, CD-ROM and web in 4-month cycles
GeoAzur IPGP		**Panagopoula landslide, year 1** 2 telemetered continuous GPS 2 seismometers 1 borehole tiltmeter	Experimental phase; CRL access to records through collaboration
OPGC		**Magnetometers** **Electrotelluric lines** **Radio**	Experimental phase; CRL access to records through collaboration

Table 1 : Main instrumental and data base resources of CRL

B4.3 Mobilization of critical mass

Res./Innov.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	total
WP1	26	28	22		6		8	70			1,9	12		5,6	19	30			228,5
WP2				3	4				3			30							40
WP3	15	3								3,3									21,3
WP4	58					18						12			4			1,9	93,9
WP 5	5		12	2			0,5		3	1		2							25,5
WP6	1,5								26			6	24						57,5
WP7								18				2							20
WP8	0,5	15	18				6	6	2				2				25		74,5
total	106	46	52	5	10	18	15	94	34	4,3	1,9	64	26	5,6	23	30	25	1,9	561,2
Demonstr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
WP1								2											2
WP2																			
WP3																			
WP4	2											2							4
WP5																			
WP6																			
WP7	34																		34
WP8																			
total	36							2				2							40
Managt.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
WP1	3	1	0,1		0,15		0,3	2			0,1	1		0,1	1	2			10,75
WP2	0,5			0,15	0,15				2			1							3,8
WP3	1									0,1									1,1
WP4	4					0,5												0,1	4,6
WP5	0,5		0,5	0,15					2	0,1			1,5						4,75
WP6	0,5								2										2,5
WP7	1																		1
WP8	0,5	1	0,2				0,2						0,5				2		4,4
total	11	2	0,8	0,3	0,3	0,5	0,5	2	6	0,2	0,1	2	2	0,1	1	2	2	0,1	32,9
total	153	48	52,8	5,3	10,3	19	15	98	40	4,5	2	68	28	5,7	24	32	27	2	634,1

Table 2: STREP man-month project effort

The man-month effort (total 634) is equivalent to 26 full-time persons on the two year project.

B4.4 Adequation of financial plan

- **Budget balance**
  - ***Global level of requested funding from EC.***

    The requested EC grant is at the highest level for STREP projects: this is is due to the large number of participants, itself related to the exceptional and attractive character of the Corinth natural laboratory. An alternative solution was to cut the project into two projects, with EC budgets around 850 keuros each. One would have been aimed at long and short term multirisk assessment, the other at multirisk alarm development, involving still more than 10 participants each (many in both projects). A large number of interactions (instrument sharing, data sharing, common data analysis, cross-interpretation) would not have been supported anymore within each individual project, leading to a significant reduction in the number and quality of the deliverables. The productivity gain is expected to be much higher with a single project: **integration** is a key word of FP6, and we follow this idea with 3HAZ-Corinth.

- ***General balance between countries:***

France is taking the largest part, followed by Greece and Italy. Other countries have more modest budget, but propose very valuable expertise in their field, not covered by the other partners. The budget of France should be seen as three components: coordination; contribution to CRLNET and GPS; other research topics. CRLNET and the continuous GPS arrays are technological inputs at the heart of the CRL project, producing the most detailed image of current seismicity and deformation. The related data is totally open to public, with no restriction, contrary to the data from all other participants (except CUP). The E.C. grants for improving their quality thus directly benefits the whole geophysical community. Removing this input, together with the coordination budget, from the total grant received by France, restores a better balance between France, Italy, and Greece.

- ***General balance between hazards:***

The budget share between hazards is in proportion to their respective level of risk. The dominant part is therefore for seismic hazard. The reduced effort for landslide is also for avoiding duplication with some components of the LEWIS project.

- ***Optimization:***

In order to increase synergy and reduce the costs, most instruments are common for several objectives: seismic arrays serve all hazards; GPS stations serve seismic and landslide hazard; marine exploration will serve slope failure analysis, tsunamis, and seismic hazards.

- ***Instrumental input :***

The EC grant should be seen also in regards of the data and instrumental input provided by the partners. The equivalent budget can be quantified for the existing array: the equipment cost of the presently continuously monitoring instruments (Table 1) is about 1 Meuros (plus 2 Meuros if one counts the AIG10 deep borehole drilling and instrumentation.).

	seismic	tectonic	geodesy	transier	landslic	tsunam	instrum	alarm			
	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	overh.*	coord	total
IPGP	63	0	85	165,8	4	5	30	0	57,2	35	445
ENS	20	0	15	0	0	0	0	60	14		109
GEOAZUR	7	0	0	0	85	0	0	70	15		177
IFP	0	25	0	0	20	0	0	0			45
IRSN	20	0	0	0	0	0	0	0			20
UP6		0	0	25	0	0	0	0			25
UPATRAS	82	0	0	0	2	0	0	34			118
NKUA	30	0	0	0	0	10	0	46	14		100
HCMR	0	15	0	0	15	100	0	0			130
NOA	0	0	10	0	0	8	0	0			18
AUTH	10	0	0	0	0	0	0	0			10
INGV	50	60	0	75	5	0	0	0	30		220
UNIBO	0	0	0	0	0	65	0	0			65
WAPMERR	50	0	0	0	0	0	0	0			50
NUID	60	0	0	0	0	0	0	0			60
CUP	50	0	0	0	0	0	0	4	12		66
NEURON	0	0	0	0	0	0	0	55			55
OPGC	0	0	0	10	0	0	0	0			10
	442	100	110	275,8	131	188	30	269	142,2	35	
											1723

Table 3: Requested grant from E.C (keuros), per Work-Package and Partner

	personal	travel	equipt	consuma	subcon	overh. *	total EC
IPGP	46	52	74	114	101,8	57,2	445
ENS	61	19	15	0	0	14	109
Nice	47	17	50	45	10	8	177
IFP	32,5	4	0	4,25	0	4,25	45
IRSN	0	20	0	0	0		20
UP6	0	10	8	2	5		25
UPATRAS	20	4	56	9	12	17	118
NKUA	60	10	25	5	0		100
HCMR	130		0	0	0		130
NOA	3	7	0	8	0		18
AUTH	5	3	2	0	0		10
INGV	70	65	0	15	25	45	220
UNIBO	42	9,2	0	3	0	10,8	65
WAPMEF	40	2	0	0	0	8	50
NUID	36	4	20	0	0		60
CUP	36	15	0	3	0	12	66
NEURON	50	5	0	0	0		55
OPGC	0	4	0	4,5	0	1,5	10
	678,5	250,2	250	212,75	153,8	177,75	
							1723

Table 4. Requested grant from E.C (keuros), per financial post

* when blank in column "overh.", overhead is included in the numbers of the other columns

4.5 Main subcontraction:

1. Observatoire Midi-Pyrénées (OMP) (subcontractant INGV)

- repeated measurements of the H2 profiles across the Aigion, Heliki, and Psathopyros faults (1rst survey October 2003)
- continuous measurement of H2 in soil

***2.* Geosciences Rennes UMR 6118 (subcontractant UP6)**

- modeling of groundwater perturbation induced by strain

3. National Technical University of Athens (NTUA) (subcontractant IPGP)

The geodetic work of WP3 will be done in cooperation with NTUA as subcontractant. NTUA remains an active member of CRL.

4. Carnegie Institution of Washington (subcontractant IPGP)

This institution has 20 years of technological expertise in constructing the Sacks-Evertson strainmeter. One of the most sensitive and reliable strainmeter worldwide One such instrument has been already successfully integrated in the CRL arrays.

- Construction of the borehole strainmeter/dilatometer

5. EDAFOMICHANIKI, geotechnical company, Athens (subcontractant of GeoAzur)

This company has done several geotechnical and geological studies of the Panagopoula landslide. It is in charge of the landslide monitoring (about 10 boreholes with repeated tilt measurement, twice a year). We propose:

- new specific geotechnical and geological studies of the landslide
- to negotiate accessibility to the existing boreholes for CRL instrumentation

6. Drilling companies, not yet identified (subcontractant of Upatras, IPGP)

- Drilling for the seismometers and the strainmeters

7. Hydrogeological studies (subcontractant of UP6)

- Hydrogeology, University of Patras
- Institut of Geology and Mineral Exploitation of Greece, department of Hydrogeology

B.5 Project management

B5.1 Steering committee:
- Coordinator, Pascal Bernard
- responsible scientists for WP
- the scientific leader of each partner, if not a WP leader

B5.2 Meetings:
- Plenary meetings: kick off, one year, two years, end meeting –
- dedicated workshop at mid-term for scientific discussion on results, adjustments of tasks, links with other projects (ASSEM, AEGIS, + new ones)
- regular meetings (mostly in Paris, Athens, Rome, Aigion, and Patras) with the scientist responsible for Workpackages.

B5.3 Communication between and within work packages
The coordinator checks regularly the availability of data from one workpackage as input to the other, in due time.

Logistic:

The coordinator checks the quality of a web page updated for information on dates and objectives of coming field work.

It helps and contributes to the coordination of field activity between WPs.

Scientific:

The coordinator checks the production of an internal webpage for:
- o daily location of seismicity with the CRLWEBNET data (selection of SATNET, CRLNET, and ATHNET telemetered records).
- o Daily, weekly, or monthly updated pdf plots of continuous signals from selected stations (strain, tilt, aquifer pressure, geochemical site, ….)
- o in case of significant earthquake: acceleration maps estimates, preliminary models of the source, within a few days.
- o results of the “alarm” (WP8)

Internal reports:

- Bimestrial assessment of progress, sent from all to all participants:
  - o achieved instrumentation and field work, delays, difficulties, data analysis
  - o planning of future field work dates, updated, so that the participants can adjust their own field work to meet, discuss and interact in the field with each other.
- Reply and comments by the coordinator to this bimestrial information input, in order to trigger discussions on technical or scientific topics, or request clarification, if needed.

B5.4 Conflicts
- Rapid solving of conflicts (problems of data accessibility, incompletion of tasks, …) or trouble in work progress (failure or delays in one task), through email or meetings
- In case of persisting problems (ex: failure of installation or of maintaining an instrument, unavailability of data), the coordinator will decide, after discussion with the participants and agreement of Brussels, to transfer the money from

subsequent payment, if any, to another task, or, if necessary, to another participant.

B5.5 Communication with the Commission

- Regular informal communication to the commission for progress in the work
- Discussion with the Commission in case of difficulties to achieve one of the proposed WP or deliverables.
- Contractual reports and deliverables for the commission

B5.6 Coordination with the Corinth Rift Laboratory management structure

The CRL project, which started 4 years ago, involves teams from about 50 European public and private research institutions. At the French level, this is managed as a “Groupement de Recherche” (GDR), which is a CNRS structure working as a research laboratory. The council includes the INSU/CNRS (representing the French academic sector), IFP, and IRSN. It has a Scientific Committee involving French and foreign experts from ENS (Paris), INGV, NUID, and, in the near-future, GFZ/Potsdam.
The formal, contractual links with other partners is through the on-going E.C. projects. In 2004, French, German, Italian and Greek teams will be formally associated through an official agreement between the relevant ministers.
Meanwhile, a plenary meeting of CRL is held once every two years in the city of Aigion, for presentation of results and on-going studies, and planning of future work and projects.

B5.7 Management of intellectual properties:

- Data:

One of objectives of CRL is to make public all the gathered data. For the CRLNET and GPS data, it is public access with no restriction. For some other, it is restricted to CRL participants during some time (generally 1 to 2 years), for allowing validation of the measurement and first publications, before being opened to public. The **CRL data base** distribution policy is detailed in Table 1.

The **GIS GEOLOGICAL DATABASE** (INGV) is open to CRL for background data during the project, policy for research data use specified in the database according to each contributor request.

- Technological innovation

Patent for borehole hydrostatic tiltmeter and strainmeter after prototype testing.

B6 Workplan

a. Research, Technological development/innovation

WP1: Seismicity Monitoring and Modeling

WP1.a: Maintaining of existing arrays

- CRLNET : 1 visit every 3 weeks – Feeding data base (ENS, GeoAzur, IPGP)
- RASMON : Feeding data base - repair in one week (IRSN/NKUA)
- CORSSA : Feeding data base – immediate intervention in case of failure (IRSN/NKUA/AUTH agreement)
- CUP: maintaining the 2 existing BB stations and accelerometers - Feeding data base (CUP)

WP1.b: Installation of new stations

- ATHNET contribution: 2 BB seismometers with radio/satellite real-time link in the target area
- SATNET contribution: 2 VBB borehole seismometer in the target area, satellite/real time data (Upatras)
- SERGOULA and MAMOUSIA (Prague-Patras joint stations): installation of 2 existing BB stations in vaults
- RASMON: completion of the array by 2 accelerometers (IRSN/NKUA)
- CORSSA: completion of the array by installation of the rock site reference accelerometer (IRSN/AUTH/NKUA)
- AIG10: install the new borehole seismological equipment between 700 and 1000 m (velocimeters, accelerometer) (IPGP)

WP1.c: Data processing

- Automatic procedures for phase picking, magnitude and focal mechanisms determination (UPatras)

WP1d: Data base

- Data base for CRLNET (ENS, CNRS/GeoAzur, IPGP)
- Data base for RASMON and CORSSA (NKUA, IRSN, AUTH)
- Data base for selected stations of ATHNET, SATNET, and CUP

WP1e: Data analysis

- standard and non standard determination of location, focal mechanisms, magnitude (ENS, CNRS/GeoAzur, CUP, UPatras, NKUA, IPGP)
- relocation with double difference (CNRS/GeoAzur)
- multiplet analysis for structure and velocity changes (ENS, NUID, IPGP)
- use of multiplets to investigate the recovering time of the crust after large stress perturbations following earthquakes, by looking at the change in the late coda related to episodic fluid flow. (NUID)
- Regional and local stress analysis from focal mechanisms (NKUA, ENS, IPGP)
- Development and application of new software for source-parameter inversion from local and regional stations based on synthetic and empirical Green's functions (a multiple-source, moment-tensor formulation) (CUP)
- Analysis and modelling of the seismic motion from small moderate and strong events, in order to constrain the linear and non linear soft soil behaviour of CORSSA site (IRSN, AUTH, NKUA)
- Complete existing strong motion databases adding events recorded by CORSSA and RASMON arrays: derivation of empirical attenuation relationships for

strong motion (pseudo acceleration, or velocity) prediction (IRSN, NKUA, AUTH)
- map the homogeneity and quality of reporting in the earthquake catalogue as a function of space and time (seismicity rate changes, stability of b-values and changes in the minimum magnitude of complete reporting). Definition of that part of the catalogue (in space, time and magnitude band) that can be used for quantitative studies of seismicity patterns (WAPMERR)

WP1.f: Modeling of seismicity
- space-time characterization and interpretation of seismicity (swarms, quiescence) and other parameters (b-value, fractal dimension, etc..) (WAPMERR, IPGP, NKUA)
- models of seismicity (epidemic, generalized Omori law, cross-triggering….) (IPGP, INGV)

WP1.g: Correlation of seismicity with aseismic transients
- development of tools for automatic search for correlation patterns in large data sets (IPGP, WAPMERR)

WP1h: Hydro-mechanical models of the crust
- mechanical modelling of transients with friction law (IPGP)
- development of new numerical schemes for coupled hydro-mechanical processes, based on discrete modelling of fluid flow and granular modelling of and elastic/viscoelastic solid, with chemical feedback, to investigate the effects of transients (UCD)

WP1i: Modeling of large ruptures
- stochastic modelling of the broad-band generation of destructive waves (k-square model, composite rupture, empirical Green's Functions) (IRSN, IPGP, CNRS/GeoAzur, NKUA,AUTH)
- 3D modelling of dynamic rupture propagation across fault steps (INGV, IPGP)
- 3D models of dynamic rupture, to study the relative effects of geometric and dynamic heterogeneities (INGV)
- modelling of fault interaction through elastic stress transfer and inferences on seismicity patterns (INGV)
- Ground motion prediction from dynamic heterogeneities (INGV)

WP1j: Modelling of seismic wave amplification in Aigion Harbour
- analyze and model seismic wave propagating from 1000 m to the surface in soft soil (CORSSA-AIG1O stations) (IRSN, NKUA, AUTH)

WP1.k: Tomographic studies
- detailed tomography with waves from local earthquakes (CNRS/GeoAzur)
- geometry of active faults at depth from converted phases and multiplet geometries (ENS, CNRS/GeoAzur)

WP1.l: Dissemination activities
- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production.

WP2: Long term tectonic deformation

WP2.a Fault mapping
- Mapping of active fault traces and main geomorphic features (marine terraces, landslides, alluvial fans, alluvial valleys, etc.). Integration of data inland/offshore (INGV, HCMR, IFP)
- Mapping of offshore recent fault scarps (HCMR)

WP2b:Paleoseismicity

- Recognition and dating of earthquakes of the past by means of trenching, shallow coring, dendrochronology, and re-evaluation of historical records along with the collection of new data in the European archives (INGV, IRSN).

WP2c: Fault slip rates

- Estimate of fault slip rates based on inland/offshore fault data (INGV, HCMR).
- identification of submarine terraces, relation with onshore marine terraces, estimation of subsidence versus uplift rates (HCMR)
- Modelling of on-shore marine terraces uplift rates by means of direct dating, correlation with sea-level change curves and estimate of regional uplift, with special consideration of the "lake" periods of the gulf. (INGV, IRSN)

WP2d : Coupled erosion and sedimentation : field study and modeling

- Gravity coring and sequence stratigraphic interpretation of the sedimentary infill (HCMR)
- Field study of the faults and modelling of their activities by an inversion of the sedimentary record on the hanging wall. Quantification of the erosion and subsidence rate. The current softwares have to be adjusted for the small scale sedimentary bodies under study (IFP)

WP2.e: Global model of the quaternary tectonic deformation of the western rift of Corinth

- Update, enlargement and maintenance of the GIS Database prepared during CORSEIS (INGV).
- 3D Finite Elements modelling of the normal fault system to compute: the deformation pattern at the Earth surface including topography; pre-stress distribution on assumed fault planes caused by the regional tectonic stress field (accounting for the isotropic component); static dislocation models and comparison with geodetic observations; predicted patterns of slip by static analysis (INGV).

WP2.f: Dissemination activities

- GIS Geological Database , Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production (INGV).

WP3: Short term tectonic deformation

WP3.a: Repeated GPS at the western end of the rift

- Connection of normal faulting system to the strike-slip environment of the Patras Gulf; refined analysis of the anomalous strain gradient NE to Patras (IPGP, ENS).

WP3.b: Continuous GPS

- Add 3 stations to the 5 existing of CRL for studying the spatial gradients of secular trend, and possible transients (IPGP).

WP3.c: Systematic interferometry analysis of incoming SAR images

- identify stable pixels on the images for keeping a long term coherence and allow long term monitoring of deformation (IPGP, NOA).

WP3.d: Data analysis and modelling

- use of elastic half space and layered models (IPGP, NOA).

WP3.e: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production.

WP4: Aseismic transients and precursors

WP4.a: Maintaining the existing monitoring systems (see Table 1)

- Strain measurement: 1 SACKS-EVERTSON dilatometer at 150 m in depth, (IPGP)
- Tilt measurement: 2 perpendicular long-base, shallow hydrostatic tiltmeter (IPGP)
- AIG10 borehole: pore pressure measurement (IPGP)
- Pore pressure monitoring of 2 trapped aquifers (U Paris 6)
- INGV Geochemical monitoring at 2 artesian wells (INGV)
- Radon monitoring in soil with 9 probes on the Helike and Aigion fault scarps (IPGP)

WP4.b : Improving/completing the existing arrays (see table 1)

- 1 SACKS-EVERTSON borehole dilatometer near the Mornos delta (persistent active swarm area) (IPGP)
- 2 high resolution borehole IPGP strainmeter for noise rejection and array studies with the SACKS instruments (IPGP)
- pressure monitoring of trapped aquifers: 1 pore pressure sensor north to the Mornos delta (U Paris 6)
- geochemical spot-surveying in the Mornos delta area (INGV)
- soil gases survey throughout the entire area by profiles mainly (INGV)
- H2 monitoring on fault scarps (OMP)
- MT experiment for first km depth structure of the Trizonia island (site of many instruments) (OPGC)

WP4.c: Data analysis and modeling

- correction from meteorological noise (INGV, Uparis6, IPGP, OMP)
- correlation between observations of transients (IPGP, INGV, Uparis6, OMP)
- correlation with seismicity (IPGP, INGV, Uparis6, OMP, WAPMERR)
- search for superficial sources of E.M. noise related to seismic activity (OPGC)
- hydro-mechanical/hydrochemical modelling of transient processes (NUID, INGV)
- modelling of water-rock interaction by a mineralogical/mechanical approach (INGV)
- improving models of friction laws and fault instabilities (IPGP)

WP4.d: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production

WP5: Landslides

WP5.a: Documenting the Panagopoula landslide

- Analysis of available geotechnical studies and reports (EDAFOMECHANIKI , University of Patras,…) (CNRS/GeoAzur, IPGP, INGV)
- Detailed mapping of the landslide through air photographs and field reconnaissance (INGV)
- Hydro-geochemical survey (CNRS/GeoAzur)

WP5.b: Instrumentation of the Panagopoula landside

- selection of the optimal location for instrumentation (CNRS/GeoAzur, IPGP, INGV)
- 2 continuous GPS, 2 seismometers, 1 meteorological station, 1 borehole tiltmeter (CNRS/GeoAzur, IPGP)
- repeated pictures with digital camera (from ground level or air) (CNRS/GeoAzur)
- repeated distance and angle measurement on permanent reflectors (from ground) (CNRS/GeoAzur)
- *in situ* test the AE optic fiber for displacement detection (UPATRAS)

WP5.c: Panagopoula data analysis

- data processing for slip rate records (CNRS/GeoAzur, IPGP)
- correlation of slip rate with meteorological factors (rain) (CNRS/GeoAzur)
- correlation of slip rate with ground shaking characteristics from local earthquakes CNRS/GeoAzur)
- analysis of ground shaking induced by landslide (CNRS/GeoAzur, IPGP)

WP5.d: Modelling of slip instability

- Adjustment of friction laws on the detachment surfaces to the observations (IPGP, CNRS/GeoAzur)

WP5.e: Kinematic GPS on train

- installation of a GPS on a train on the Corinth-Patras line for repetitive, daily monitoring (IPGP)

WP5.f: Field studies for other soil hazards

- Identification of liquefaction, surface rupture, flash floods, and landslide prone areas, based on geomorphology (INGV)

WP5.g: Long term evolution of slope

- study of the coast evolution, modelling of the potential slope failure both onshore and offshore versus erosion, sedimentation and therefore climatic changes (IFP)

WP5.h: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production

WP6: Offshore slope failure and tsunamis

WP6.a: Mapping unstable offshore slopes

- Definition and search for potential tsunamigenic landslides, and geometrical characteristics of sliding masses (HCMR)

WP6.b: Marine exploration

- Marine geology-geophysics*:* high-resolution seismic and swath bathymetric investigation of active and potential submarine sliding sites and of recent offshore fault rupture, estimation of fault-slip rates (HCMR)
- slope stability of offshore landslides: down-core measurement of geotechnical properties, estimation of slope stability (HCMR)

WP6.c: Dating past tsunamis

- Recognition and dating of paleotsunami by means of onshore shallow coring and historical records. Sites for investigations will be selected following the scenarios modelled by UNIBO and from historical archives (INGV, NOA)

WP6.d: Analysis of tsunami data

- analysis of historical archives (NOA, UNIBO)

- analysis of the 1999- 2003 tide-gage records for quantification of free basin oscillations and identification of small unreported tsunamis (UNIBO, IPGP)
- installation of a new tide-gage with telemetry (IPGP, UPatras)
- underwater acoustic monitoring of slope failure (NKUA)

WP6.e: Numerical modeling of scenario tsunamis

- landslide triggering source: A block –based Lagrangian model is used to compute the sliding body dynamics, from the estimates of the sliding body geometry (size, shape, position, etc.) and rheology (UNIBO)
- earthquake triggered source: elastic modeling of sea bottom from scenario earthquakes (UNIBO)
- tsunami propagation, with a finite-element shallow-water hydrodynamical based on accurate topography and bathymetry data (UNIBO, HCMR)
- analysis of the tsunami impact at the Aigion harbour with special fine-grid tsunami simulations to estimate the extension of the inundation zone in the urban area (UNIBO, HCMR)

WP6.f: Under water monitoring of slop failure

- acoustic waves for slump and transients (NKUA)

WP6.g: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production

WP7: Sensor-innovation and demonstration

WP7.a: Development of high-resolution sensors for deformation

- low-cost, borehole strainmeter, resolution 10^{-9} (IPGP)
- low-cost, borehole bi-liquid tiltmeter, resolution 10^{-9} radians (IPGP)

WP7.b: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production.

WP8: CRL information systems: Alarms, Webpage, and Data Base

WP8.a: New telemetry on CRL arrays

Satellite

- ATHNET : radio/satellite real-time link for 2 BB stations (NKUA)
- SATNET : satellite real-time connection for 2 VBB (UPATRAS)
- One tide-gage connected to SATNET (UPATRAS, IPGP)
- One borehole strainmeter connected to SATNET (UPATRAS, IPGP)

Telephone line

- CRL NET: ADSL for 4 stations (GeoAzur, NEURON)
- RASMON (IRSN/NKUA)
- CORSSA (IRSN/AUTH/NKUA)
- AIG10 (IPGP)
- New continuous GPS (IPGP)

WP8.b Development of software for near-real time alarms

- Development and validation of software for near-real time determination of location and magnitude from P and S waves from the CRL-SA subarray (selected stations for **S**eismic **A**larm). Synthetic records of target large earthquakes will be produced using local records and empirical Green Function techniques (CNRS/GeoAzur, IPGP,CUP)
- development of software for production of peak acceleration maps near-real time from records and earthquake source information (NKUA, CUP, NEURON)
- development of software for production of coastal flooding maps in near-real time from records and earthquake source information (UNIBO, NEURON)

WP8.c Implementation and test of alarm on the acquisition systems

- integration of stations from SATNET (2 stations) and ATHNET (5 stations) (CRL-SA subarray) in near-real time for production of alarms: location and magnitude (NEURON, UPATRAS, NKUA)
- implementation of an alarm system on the continuous data flow of the new tide-gage (integrated to SATNET by radio-link at one new VBB site) (NEURON, UPATRAS, IPGP)
- test of feasibility of an alarm system on the Panagopoula landslide (CNRS/GeoAzur, IPGP, NEURON)

WP8.d Seismic hazard Web page of CRL-WEBNET

- integration of data from seismic stations of SATNET (2 stations), PATNET (2), CRLNET (4), and ATHNET (3) . Telemetered seismograms (satellite or modem) are automatically picked for a daily determination of local seismicity. (NEURON, CNRS/GeoAzur)
- automatic integration of the seismic alarm from CRL-SA, if any.
- Automatic integration of the "alarm" acceleration map from CRL-SA (NEURON, CNRS/GeoAzur)
- Automatic integration of the daily seismicity (CNRS/GeoAzur)
- Integration of continuous records of selected sites, and records of selected events, updated weekly (CNRS/GeoAzur)

WP8.e Tsunami hazard Web page of CRL-WEBNET

- Automatic integration of the tsunami alarm (WP8.a) (CNRS/GeoAzur)
- Automatic integration of tsunami coastal flooding prediction from earthquake information (UNIBO, CNRS/GeoAzur)
- Integration of continuous records of the tide-gage, and records of selected events, updated weekly (IPGP, CNRS/GeoAzur).

WP8.f Landslide hazard Web page of CRL-WEBNET

- Integration of continuous records of the GPS position, updated daily (CNRS/GeoAzur, IPGP)

WP8.*g *CRL Data Bases access through CRL-WEBNET

- creating links to existing data bases

WP8.h End-Users of Alarms and CRLWEBNET

- identification of end-users (civil protection, local authorities, Rio-Antirio bridge service, Railway traffic service,…) (NEURON, NKUA, Upatras)
- definition of seismic alarms thresholds with end-users (NKUA, Upatras, CNRS/GeoAzur, ENS, CUP, IPGP, NEURON)
- definition of tsunami alarms thresholds with end-users (UNIBO, IPGP, NEURON)
- definition of landslide threshold alarms with end-users (CNRS/GEOAZUR, IPGP, NEURON)

- evaluation of the alarms performance with end-users in the course of the project

WP8.i: Dissemination activities

- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production

b. Demonstration activities

WP7: Sensor -innovation and demonstration

WP7.c: Demonstration of instruments

- Long-base hydrostatic tiltmeter, installed in 2003 in the Trizonia island, resolution 10^{-9} radians (IPGP)
- portable radon sensor for liquid and gas phases (INGV)
- CO_2 sensor for Geochemical Monitoring Systems (GMS) (INGV)
- testing the daily kinematic GPS system on commercial railway traffic (IPGP)

WP7.d: Dissemination activities

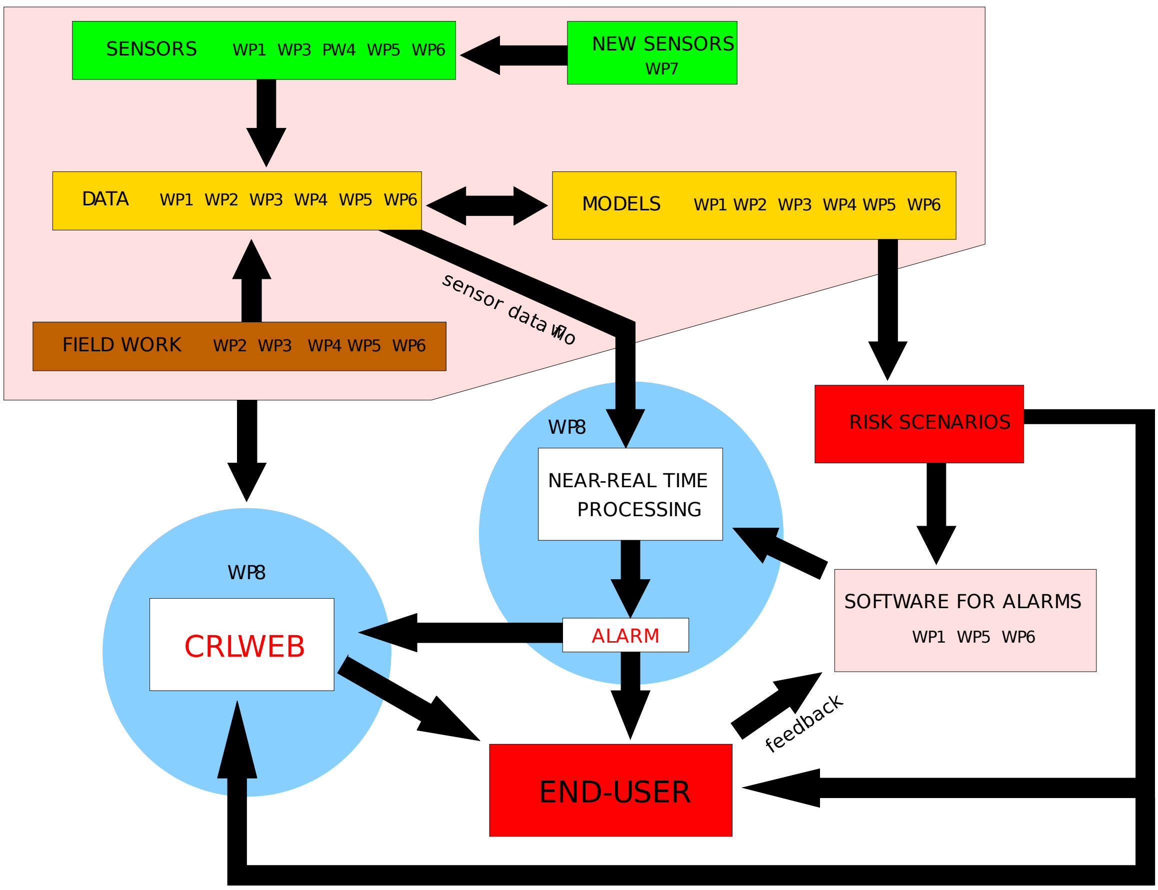
- Publications, Conferences, workshops, contribution to CRL web site, acquisition of film images from field work for CNRS production.

c Project management activities/ assessment of progress& results

activity	month																						
WP1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1a	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1b			X	X	X	X	X	X	X	X	X	X												
1c	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1d	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1e	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1f	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1g	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1h	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1i *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1j														X	X	X	X	X	X	X	X	X	X	X
1k	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1l						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP2																								
2a						X	X	X	X	X	X	X	X											
2b						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2c						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2d	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2e																		X	X	X	X	X	X	X
2f						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP3																								
3a								X	X															
3b	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3c						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3d	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3e						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP4																								
4a	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4b							X	X	X	X	X	X	X	X	X	X	X	X						
4c	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4d						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP5																								
5a	X	X	X	X	X																			
5b						X	X	X	X															
5c								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5d														X	X	X	X	X	X	X	X	X	X	X
5e						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5f							X	X	X	X														
5g	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5h						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP6																								
6a	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

6b							X	X	X	X	X	X	X	X	X	X	X	X	X					
6c							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
6d			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6e						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6f													X	X	X	X	X	X	X	X	X	X	X	X
6g						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP7																								
7a	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7b						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7c	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7d						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WP8																								
8a						X	X	X	X	X	X	X	X											
8b	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8c					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8d				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8e											X	X	X	X	X	X	X	X	X	X	X	X	X	X
8f															X	X	X	X	X	X	X	X	X	X
8g				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8h	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8i						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(WP1i * : in case of local moderate to large earthquake)



Graphical representation of WP interdependence

Management through the CRLWEB net

This web site will be used for management activities (see B5)

Main risk related to the WPs

- WP1, WP3 and WP4 monitoring arrays

The risk of stations failure is large, but number and redundancy of stations of a single array, and the redundancy in the different arrays makes it relatively without critical consequences on the final deliverables.

- WP5:

- There may be delays to have the official authorization from PATHE (High-way department of the Minister) for having access to the existing reports on the Panagopoula landslide. This will be compensated by field surveys and specific subcontracting to the company which is monitoring the landslide (EFADOMECHANIKI).
- The "alarm" task may not be successful if the continuous monitoring stations are not in the appropriate location on the landslide. However, our repeated surveys should allow to define the best place for an alarm at the end of the project.

- WP6

A significant effort will be put on the installation and telemetry of the new tide-gage, to avoid failure, as it will be the single tide input for alarm testing.

- WP8

The difficulties of near-real time alarm implementation drastically increases when reducing the time lag from minutes to seconds, due to telemetry and signal processing problems. We aim at reaching the shortest times, but we cannot guarantee due to the heterogeneities of the present acquisition systems. Alarms at tens of seconds or even a few minutes are still very useful for end-users.

Work package list (full duration of project)

Work-package No[1]	Work package title	Lead contractor No[2]	Person-months[3]	Start month[4]	End month[5]	Deliv-erable No[6]
WP1	SEISMICITY MONITORING AN MODELING	2 ENS	241.25	0	23	1 to 29
WP2	LONG TERM TECTONIC DEFORMATION AND HAZARD	12 INGV	43.8	0	23	30 to 41
WP3	SHORT TERM TECTONIC DEFORMATION AND HAZARD	1 IPGP	22.4	0	23	42 to 46
WP4	ASEISMIC TRANSIENTS AND PRECURSORS	1 IPGP	102.5	0	23	47 to 58
WP5	LANDSLIDES	3 GeoAzur	30.25	0	23	59 to 72
WP6	OFFSHORE SLOPE FAILURE AND TSUNAMIS	9 HCMR	60	0	23	73 to 81
WP7	SENSOR INNOVATION AND DEMONSTRATION	1 IPGP	55	0	23	82 to 88
WP8	CRL ALARMS and WEB	17 NEURON	78.9	0	23	89 to 109
	TOTAL		634.1			

Deliverables list (full duration of project)

[1] Work package number: WP 1 – WP n.
[2] Number of the contractor leading the work in this work package.
[3] The total number of person-months allocated to each work package.
[4] Relative start date for the work in the specific work packages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[5] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[6] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the work package: D1 - Dn.

Deliverabe No[7]	Deliverable title	Deliv date [8]	Nature [9]	Dissemination level [10]
1	2 new BB seismometers with radio/satellite real-time link in the target area, ATHNET	6	O	CO
2	2 new VBB borehole seismometer in the target area, satellite/real time data, SATNET	6	O	CO
3	2 new vaults for installation of Prague-Patras BB stations	12	O	CO
4	2 new accelerometers for RASMON	12	O	CO
5	1 rock reference accelerometer for CORSSA	12	O	CO
6	1 new borehole seismological equipment in AIG10	12	O	CO
7	Automatic procedures for phase picking, magnitude and focal mechanisms determination	23	O	PU
8	Data base for CRLNET	23	O	PU
9	Data base for continuous GPS	23	O	PU
10	Data base for RASMON and CORSSA	23	O	RE
11	Data base for selected stations of ATHNET and SATNET	23	O	RE
12	Data base for selected stations of CUP	23	0	PU
13	Earthquake catalogue (location, magnitude, focal mechanism)	23	R	PU
14	Models and maps of seismicity changes	23	R	PU
15	Models of crustal velocity changes	23	R	PU
16	New software for source-parameter inversion	23	R	PU
17	Models of non linear soft soil behaviour of CORSSA site.	23	R	PU
18	Empirical attenuation relationships for strong motion (pseudo acceleration, or velocity)	23	R	PU
19	Tools for automatic search for correlation patterns in large data sets	23	R	PU
20	New mechanical models of transients with friction law	23	R	PU

[7]Deliverable numbers in order of delivery dates: D1 – Dn

[8] month in which the deliverables will be available. Month 0 the start of the project, and all delivery dates being relative to this start date.

[9] Please indicate the nature of the deliverable using one of the following codes:

R = Report
P = Prototype
D = Demonstrator
O = Other

[10] Please indicate the dissemination level using one of the following codes:

PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

21	New numerical schemes for coupled hydro-mechanical processes,	23	R	PU
22	Stochastic modelling of the broad-band generation of destructive waves	23	R	PU
23	3D models of dynamic rupture propagation across fault steps 3D models of dynamic	23	R	PU
24	Models of fault interaction through elastic stress transfer	23	R	PU
25	Ground motion prediction models from dynamic heterogeneities	23	R	PU
26	Modelling of seismic wave amplification in Aigion Harbour	23	R	PU
27	Integration of new data for the seismic tomography	23	R	PU
28	Geometry of active faults at depth	23	R	PU
29	Publications, Conferences, workshops, CRL web site, film for WP1	23	R	PU
30	Maps of active faults, landslides, and marine terraces	23	R	PU
31	Maps of offshore recent fault scarps	23	R	PU
32	Dating of paleoearthquakes	23	R	PU
33	Estimates of fault slip rates	23	R	PU
34	Maps of submarine terraces	23	R	PU
35	Estimates of subsidence versus uplift rates	23	R	PU
36	Models of on-shore marine terraces uplift rates	23	R	PU
37	Models and quantification for coupled erosion and sedimentation	23	R	PU
38	Stratigraphic sequence interpretation of the sedimentary infill	23	R	PU
39	Update, enlargement and maintenance of the GIS Geological Database	23	R	PU
40	3-D Finite Elements modelling of the normal fault system	23	R	PU
41	Publications, Conferences, workshops, CRL web site, CNRS film for WP 2	23	R	PU
42	Map of the deformation of the rift from GPS	23	R	PU
43	3 new continuous GPS stations	12	O	CO
44	Set of stable pixels for InSAR long term stability	23	R	PU
45	Elastic models of the observed deformations	23	R	PU
46	Publications, Conferences, workshops, CRL web site, film for WP3	23	R	PU
47	3 new borehole strainmeters	18	O	CO
48	1 pressure sensor in trapped aquifers	12	O	CO
49	Geochemical map survey of the Mornos delta area	12	R	PU
50	Soil gases survey throughout the entire area	12	R	PU
51	Continuous records of H2 on fault scarps	23	R	PU
52	Electrical structure of Trizonia island	12	R	PU

53	Correlation between seismicity and transient	23	R	PU
54	Identification of superficial sources of E.M. noise related to seismic activity	23	R	PU
55	Hydro-mechanical/hydrochemical models of transients	23	R	PU
56	Models of water-rock interaction	23	R	PU
57	Improved models of friction laws	23	R	PU
58	Publications, Conferences, workshops, CRL web site, film images for WP4	23	R	PU
59	Detailed Map of the Panagopoula landslide	6	R	PU
60	Hydro-geochemical survey of the Panagopoua landslide	12	R	PU
61	2 continuous GPS on and near the Panagopopla landslide	12	O	CO
62	2 seismometers on and near the Panagopoula landslide	12	O	CO
63	1 borehole tiltmeter in the Panagopoula landslide	12	O	CO
64	Validation of the AE optic fiber sensor in the landslide	23	R	CO
65	Slip rate records and maps	23	R	RE
66	Correlation and modelling of slip rate with meteorological factors	23	R	PU
67	Correlation and modelling of slip rate with ground shaking	23	R	PU
68	Characterization and modelling of seismic waves from the landslides	23	R	PU
69	Daily time-evolution of the Corinth-Patras railway track position.	23	R	RE
70	Maps of places of liquefaction, surface rupture, flash floods, and landslide prone areas	23	R	PU
71	Models of the potential slope failure both onshore and offshore	23	R	PU
72	Publications, Conferences, workshops, CRL web site, film on WP5	23	R	PU
73	Maps of potential offshore sliding sites	23	R	PU
74	Estimates of slope stability of offshore landslides	23	R	PU
75	Dating of paleotsunami	23	R	PU
76	Catalogue of small tsunamis from tide-gage analysis	23	R	PU
77	New tide-gage	8	O	CO
78	New hydrophone for acoustic monitoring of slope failure	12	O	CO
79	Tsunami propagation for the Corinth gulf	23	R	PU
80	Scenario of tsunami impact at the Aigion harbour	23	R	PU
81	Publications, Conferences, workshops, CRL web site, film for WP6	23	R	RE
82	Prototype of low-cost, borehole strainmeter	23	p	CO

83	Prototype of low-cost, borehole bi-liquid tiltmeter,	23	p	CO
84	Demonstration of long base hydrostatic tiltmeter,	23	R	PU
85	Demonstration of portable radon sensor for liquid and gas phases	23	R	CO
86	Demonstration of CO_2 sensor for Geochemical Monitoring Systems (GMS)	23	R	CO
87	Evaluation of the daily kinematic GPS system on commercial railway traffic	23	R	PU
88	Publications, Conferences, workshops, CRL web site, film for CRL for WP7	23	R	PU
89	ATHNET : radio/satellite real-time link for 2 BB stations	6	O	CO
90	SATNET : satellite real-time connection for 2 VBB	6	O	CO
91	One tide-gage connected to SATNET	10	O	CO
92	One borehole strainmeter connected to SATNET (UPATRAS, IPGP)	12	O	CO
93	ADSL for 4 CRL stations	12	O	CO
94	Modem for RASMON	6	O	CO
95	Modem for AIG10	12	O	CO
96	Modem for the new GPS	12	O	CO
97	New software for near-real time seismic alarms	12	R	PU
98	New software for near-real time peak acceleration maps	12	R	PU
99	New software for near real time maps of coastal flooding	16	R	PU
100	Alarm system evaluation for the CRL-SA subarray	23	R	PU
101	Alarm system evaluation for tide-gage/SATNET	23	R	PU
102	Alarm system feasibility study of the Panagopoula landslide	23	R	PU
103	Web page of CRL-WEBNET with daily local seismicity	23	R	PU
104	Web page with continuous records and selected events from the arrays	23	R	PU
105	Web page integration of the alarms	23	R	PU
106	Seismic alarms thresholds defined with end-users	23	R	PU
107	Definition of landslide threshold alarms with end-users	23	R	PU
108	Evaluation of the alarms performance with end-users	23	R	PU
109	Publications, Conferences, workshops, CRL web site, film images for WP8	23	R	PU

package description (full duration of project)

Work package number	1	Start date or starting event:	0

Participant id	1	2	3	5	7	8	11	12	14	15	16
Person-months per participant	29	29	22.1	6.15	8.3	74	2	13	5.7	20	32

Objectives

Seismicity Monitoring and Modeling

Record, analyse, and model the short term seismicity. Improve seismic hazard assessment.

Description of work

Maintaining of existing arrays ; Installation of new stations; Data processing;
Feeding data base; Data analysis; Modelling of seismicity;
Correlation of seismicity with aseismic transients; hydro-mechanical models of the crust
Modelling of large ruptures; Modelling of seismic wave amplification in Aigion Harbour
Tomographic studies.

Deliverables

1 to 29

Milestones[11] and expected result

installation of new instruments, completed month 12.

Better understanding and prediction of the seismicity

[11] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	2	Start date or starting event:	0

Participant id	1	4	5	9	12
Person-months per participant	0.5	3.15	4.15	5	31

Objectives

Long term tectonic deformation

Quantify fault activity and improve long term seismic hazard assessment

Description of work

Fault mapping; Paleoseismicity; Fault slip rates
Coupled erosion and sedimentation : field study and modelling
Global model of the quaternary tectonic deformation of the western rift of Corinth

Deliverables

30 to 41

Milestones[12] and expected result

Quantification of fault activity and catalogue of paleoearthquakes

[12] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	3	Start date or starting event:	0

Participant id	1	2	10
Person-months per participant	16	3	3.4

Objectives

Short term tectonic deformation

Measure and model the present tectonic strain field of the rift

Description of work

Repeated GPS at the western end of the rift:
Continuous GPS
Systematic interferometry analysis of in-coming SAR images
data analysis and modelling

Deliverables

42 to 46

Milestones[13] and expected result

Installation of new GPS, month 9
Better knowledge of the fault zones which slip aseismically, and how they load the upper crust

[13] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	4	Start date or starting event:	0

<u>Participant id</u>	1	6	12	15	18
Person-months per participant	64	18.5	14	4	2

Objectives

<u>Aseismic transients and precursors</u>

Detect and understand the physical mechanisms at the origin of transient processes, in particular the cross-triggering with earthquakes, including precursory phenomena.

Description of work

<u>WP4: Aseismic transients and precursors</u>

Maintaining the existing monitoring systems
Improving/completing the existing arrays, in particular the strainmeter array
Data analysis and modelling

Deliverables

47 to 58

Milestones[14] and expected result

Installation of strainmeters completed in month 18.

To obtain good quality records of some transients, with enough data to propose reliable mechanical models.

package description (full duration of project)

[14] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Work package number	5	Start date or starting event:	0

Participant id	1	3	4	7	9	10	12
Person-months per participant	5.5	12.5	2.15	0.5	5	1.1	2

Objectives

Landslides

Monitor, measure and model the effect of earthquake shaking on landslides

Description of work

- documenting the Panagopoula landslide; instrumentation of the Panagopoula landside; Panagopoula data analysis; Modelling of slip instability and landslide dynamics.

kinematic GPS on train

field studies for other soil hazards

long term evolution of slope

Deliverables

59 to 72

Milestones[15] and expected result

Instrumentation completed month 9
Observations and models of landslide sensitivity to seismic waves

[15] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	6	Start date or starting event:	0

Participant id	1	9	12	13
Person-months per participant	2	28	6	24

Objectives

Offshore slope failure and tsunamis

Predict sites and amplitude of offshore slope failure, and related tsunamis. Predict the impact of tsunamis on the coast from offshore slope failure and from earthquakes.

Description of work

mapping unstable offshore slopes; marine exploration
dating past tsunamis; analysis of tsunami data
numerical modelling of scenario tsunamis
under water monitoring of slope failure

Deliverables

73 to 81

Milestones[16] and expected result

Marine exploration – precise date unplanned yet – for new refined images of unstable slopes
Better tsunami hazard assessment in the Gulf of Corinth, and better understanding of conditions of offshore slope stability.

[16] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	7	Start date or starting event:	0

Participant id	1	8	12
Person-months per participant	35	18	2

Objectives

Sensor -innovation and demonstration

Develop new sensors for improved monitoring of the environment

Description of Work:

innovation:

- development and test of hig-resolution sensor prototypes for deformation: borehole hydrostatic titmeter and strainmeter

demonstration :

- of long base tiltmeter in Trizonia island
- portable radon sensor for liquid and gas phases
- CO_2 sensor for Geochemical Monitoring Systems
- testing the daily kinematic GPS system on commercial railway traffic (IPGP)

Deliverables

82 to 88

Milestones[17] and expected result

Validated prototypes, to be tested in situ in the target area

Operational instruments after demonstration

[17] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

package description (full duration of project)

Work package number	8	Start date or starting event:	0

Participant id	1	2	3	7	8	9	13	17
Person-months per participant	1	16	18.2	6.2	6	2	2.5	27

Objectives

CRL information systems:
Development of Alarms systems, CRL Webpage,
and improvement of Data Base accessibility

Description of work

Install new telemetry on CRL arrays: Satellite and Telephone line
Development of software for near-real time alarms
Implementation and test of alarm on the acquisition systems
Build Seismic hazard Web page of CRL-WEBNET
Build Tsunami hazard Web page of CRL-WEBNET
Build Landslide hazard Web page of CRL-WEBNET
Provide CRL Data Bases access through CRL-WEBNET
End-users for Alarms and CRL-WEBNET

Deliverables
89 to 109

Milestones[18] and expected result

month 13, installation of near-real time telemetry completed.
Improvement and validation of alarm systems with end-users
Complete and fast information flow through CRLWEBNET

[18] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

B.7 Other issues

Potential ethical issues:

CRL, and hence 3HAZ-Corinth, does not intend to make any public short term prediction, even if mechanical models of transient-to-earthquake transitions can be proposed and tested against observations.

EC-policy related issue:

Readiness to engage awareness, societal implications:
Our project will continue developing synergies with education at all levels:

General public:
Conferences, interviews, films (CNRS project), articles and books for general public

Schools:
Conferences in primary and high schools in Greece, Italy, and France

Higher education:
Training of undergraduate students, PhDs, and postdocs to field work, geophysical instruments, and modelling of earth processes; making the students and researchers aware about the applicability of their work and its importance to end-users in the domain of natural hazards.