



## **The Sinkhole of Camaiore (Lu - Toscana- Italia)**

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Natural hazards potentially affecting the municipal territory of Camaiore, in province of Lucca (Tuscany – Italy) are well-known due to its geological structure and morphological characteristics which cause an hydrogeological instability of this area. In the past, many landslides in the hinterland happened with sometimes very high economical repercussions. Moreover the plain areas suffer of floods and of other different instabilities. In particular, an atypical event happened during the fall of 1995. A sinkhole of about 35 meters of diameter involved the urban area of Camaiore causing 2,2 million of Euro damages and by chance no victims. The parossistic event occurred during the night between the 14<sup>th</sup> and the 15<sup>th</sup> October, in the middle of the town and caused the sinking of a big house and the serious damage of 5 buildings around the sinkhole. Afterwards they had to be demolished .

From 1995 up to now, the phenomenon was intensely studied from different points of view (geological, hydro-geological, structural, geophysical, geochemistry etc.) and today many others areas affected by the sinkhole problem have been detected inside the urbanized district. The knowledge acquired allowed to design and to implement an integrated monitoring system.

The system rely basically on three monitoring sub-systems: a) a continuous seismic monitoring network, getting data from three different sensors located in strategic points of the Camaiore plain; b) a periodic monitoring, sometimes continuous, of the water table of the aquifer through water-level tapes or transducers; c) a periodical evaluation of the micro-deformations of soil through GPS check points.

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At present, the seismic sensor of the monitoring system is managed automatically, while the other sensors still request a manual reading. However the manual check could loose, for different reasons, continuity and effectiveness, with the risk to delay and/or break the monitoring process, making it useless.

The first target of the next step is to implement the monitoring network with more sophisticated systems allowing a fully automatic detection of the premonitory signs (“precursors”) of impending disaster.

The management of this new monitoring system will demand the formation and training of some professional figures. These technicians will be working in the Public Administration on the processing and interpretation of the data gathered by the automatic system. This job will be carried out in collaboration with the local authority that will coordinate the monitoring activities.

The main target of this project is to set up an effective methodology of monitoring and alert to prevent the hazards potentially impending over the urban area of Camaiore. This continuous monitoring should also permit the planning of appropriate actions of building regulations to assure the public safety in the sinkhole risk areas already known or detectable in the future.

To this purpose, it’s important both the knowledge and analysis of some key parameters (physic and geologic parameters), and the gathered past experiences about the factors leading to the identification this kind of phenomena. All this has a very high strategic relevance, in particular regarding the following aspects:

- Preliminary risk evaluation with reference to the areas with peculiar features;
- The existence of cavities or low density layers inside the alluvial deposits and carbonate bedrock;
- The setup of the integrated monitoring system;
- The managing of data and the elaboration of risk maps through the Geographic Information System (GIS) ;
- The establishment of appropriate “hazard zonations” and urban regulations;
- The setting up of evacuation plans;
- The handling of emergency phases.

The new monitoring system will be based on the continuous monitoring of three specific sub-system:

1. **The soil**, checking the morphological micro-deformation in significant points, in fact it is proved that they are the main precursors of any collapse. The monitoring activities will be performed with the SAR differential interferometry with a ground based sensor, that is able to generate displacements maps, so the measurements are spatially distributed. GPS sensors that acquire data in discrete significant points will also be used.
2. **The underground**, with the implementation of sensors able to detect seismic signals, in order to discover the area source of the pulse, joined to deep deformation sensors (inclinometers) and with specific sensors for the detection of the concentration of different endogenous gases.
3. **The underground water**, with the implementation of new transducers and multi-parametric probes located in significant points to continuously acquire both the water bed variation and the chemical-physic parameters (markers).

This new sensor network will be obviously integrated and interfaced with both the weather stations and the periodic measurements of density changes detected by the micro-gravimeters.

Based upon the up to now information and the experience acknowledged about the Camaio area, the continuous monitoring activity of some peculiar parameters that concur to define the overall geological description of the phenomenon. This seems to be the only resource for the setting up of the security plan needed to ensure citizens' safety in case of similar events. This information is necessary to program interventions both in emergency case and in the study phase, obtaining:

- The reduction of the approach and evaluation time of the problem;
- The action setting and the coordination for specific professional figures;
- The optimization of the ratio “costs/investigation”.

The project is therefore oriented to a “new” implementation of the monitoring system, that will be automatic and in real time with awake and early-warning functions that will be able to give the possibility to setup, preventively and timely, a security and/or evacuation plan.