THE TELLUS PROJECT, A STUDY OF SEISMIC PRECURSORS

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ABSTRACT

The Tellus project is aimed to study, on the basis of data detected from the ground, what happens during the phase preceding an earthquake, and subsequent correlation with available data received from space thanks to satellites capable of measuring electromagnetic and thermal fields. The Tellus Project consists of multidisciplinary stations suitable for the measurement of chemical, electromagnetic, meteorological and physical parameters on Earth. In particular, the study focuses on the measurements of radon emissions on limited areas in the presence of various measuring stations (Local Area Network). The measurements of radon emissions will be collected in a specific database that will automatically be updated every hour, counting data based on registered alpha decays from radon. A specific software will be able to detect and communicate to the central hall any detected seismic anomalies. The local multidisciplinary networks will be part of the "Seismic Network Arachne Tellus" (SNAT) that will handle all the data of each Local Network. Our scientific investigation has set as its ultimate goal the identification of parameters considered "seismic precursors". The combination of data could provide a broad geophysicist framework, able to improve the current understanding of the physics of earthquakes and their processes of preparation, detectable from ground and from space.

Key words: earthquakes, framework, radon emissions, Local Network

INTRODUCTION

Large earthquakes (M 5.5 or greater) are the most devastating of all natural calamities to human life and property. The recent earthquake in Abruzzo, Italy (April 2009) has had tragic consequences for Italy.
Therefore, scientific research leading to the successful prediction of large earthquakes, sufficiently in advance, has great significance to mankind.
Unfortunately, to this date, no reliable method has been developed for the successful application of earthquake prediction, based on a geological scale, when applied to a human scale; the latter requires precise timing, location and intensity, factors not easily defined geologically.
Nevertheless, based on long-term studies, some earthquake precursors like change in ion concentration in water, variation in concentration of He, Ne, Ar, Rn and N2 in the environment of the affected zone, abnormality of behaviour in some animals, occurrence of milder foreshocks before a large earthquake, sudden water-level change in some wells, ground deformation, stress build-up in rocks (which may in turn alter electric resistance of the rocks), etc., radon emissions, have been identified, and studies began to appear since many decades [1-6].
However, most of these precursors are subject to so many different influences that they behave erratically and therefore have been poorly understood so far, making earthquake prediction a controversial issue.

The scientific detection of anomalies precursors of earthquakes and development early warning system can be possible just through the simultaneous detection of multiple factors.

Radon as a precursor

Major, erratic changes in Radon concentration have been observed in many earthquake-prone zones a few months/days before, during and after a large earthquake. Such behaviour has been observed in deep mines, cellars and wells where induced Radon concentration fluctuations due to disturbing environmental factors can virtually be ruled out. Therefore, it is tempting to consider a sudden erratic fluctuation in Radon concentration, for days on end, particularly in deep wells in an earthquake-prone zone, as a potential omen for an earthquake. [1,2,5-8]

A standard explanation for the variation in dissolved Radon concentration in faults and water wells before, during and after an earthquake in an area is the following: variation in release of the gases entrapped in crustal rocks due to pore collapse and/or opening of micro-fractures caused by stress variations.

Because of the short half-life of Radon, it is generally believed, incorrectly, that most of the naturally occurring Radon in the environment comes from only within a few tens of metres of depth in the Earth's crust. A suitable transport medium (fluids) or local environment (open fractures) can instead carry large concentrations of Radon from greater depths and over greater distances.

Variations in Radon emissions do not only depend on earthquakes, but also on the combined effects of luni-solar tides, on winds, on the humidity, the temperature, the atmospheric pressure, volcanic activity, cosmic radiations, all disturbances which must be filtered and eliminated before hoping to detect variations due to telluric events [8-9]

A multiple station Radon detection array requires an extensive, detailed survey of the geology and associated gas emissions before permanent sites, useful to possible earthquake prediction, can be established. Subsequent to recording the undisturbed emissions at these stations over several months, a very clear pattern emerges, showing the luni-solar tidal influence on the Radon emissions. Plotting the peaks, i.e. intensities and times of these emissions as a function of lunar, and not calendar month, month after month, one finds a perfect coincidence from day to day for each lunar month. This background is necessary to be able to detect anything that disturbs this smooth status quo, with Radon peaks that no longer appear synchronised.

An Italian Monitoring Stations Net

The Tellus project is aimed to study, on the basis of data detected from the ground, what happens during the phase preceding an earthquake, [10]

The Project individuates the subsequent correlation with available data received from space, thanks to satellites capable of measuring electromagnetic and thermal fields.

The integrated multidisciplinary station provides multi-method measurement approach such as:

capacity to detect the emission of Radon

measurements variation of electric and electromagnetic fields

use of the meteorological parameters

camera with optical vibration technology

Measurements both indoor and outdoor represent great asset to supply the correlation of these data and locate the detection anomalies of earthquake precursors.

The Tellus Project consists of multidisciplinary stations suitable for the measurement of chemical, electromagnetic, meteorological and physical parameters on Earth. See Figure 1.

In particular, the study focuses on the measurements of radon emissions on limited areas in the presence of various measuring stations (Local Area Network).

After collecting data for at least 12 months, it will be possible to identify and measure the background emission of the seasonal alterations - dependent on climatic factors - of which the most relevant is the change of atmospheric pressure at ground level.

The stations are all located in a special structure placed about 3 meters below ground level. Each station will also include a triaxial seismometer for the detection and identification of parameters of earthquakes with a magnitude close to zero.

The measurement of environmental parameters, in particular temperature, pressure and humidity is also part of the station. An external antenna, for the monitoring of the electrical component of the electromagnetic field in the bands ELF and VLF, is part of the equipment as well. It is thus constituted a "Local Network" that will ensure the monitoring of an area of approximately 600 km^2, in which about 14 stations will be set up.

To measure indoor Radon concentration we use the method of Continuous Radon Monitoring (C.R. of EPA). The air is diffused into a counting chamber. The counting chamber is a ionization chamber. Scintillation counts are processed by electronic equipment, and radon concentrations for predetermined intervals are stored in the instrument's memory. See Figure 3.

This detection category includes devices that record real-time continuous measurements of radon gas over a series of minutes and report the results in hourly increments.

The anomalies of number of pulses counted will be automatically identifying with our specific software (see Figure 4), which is able in real time to show the anomalies that would hardly be identifiable with the single view or with a normal data flow control.

This specific software (Radonometer) is situated in underground environment to avoid the interferences which might be caused by climatic factors.

Across our seismic network we are able to analyze the focal mechanisms of earthquakes and identify the correlation with the anomalies.

We can demonstrate how various anomaly detection analyses of several factors which fault zone could produce, can serve to pinpoint pre earthquake related phenomena.

Through the data of the Local Network, it will be compiled a database that will gather and record all the seismic events.

For the most important earthquakes, it will proceed to the verification of the correct location of the epicenter and the determination of focal mechanism that generated it.

The measurements of radon emissions will be also collected in a specific database that will automatically be updated every hour, counting data based on registered alpha decays from radon.

A specific software (AAD) will be able to detect and communicate to the central hall any detected seismic anomalies.

The choice of the parameters that are input to the software are the result of a research activity conducted in the previous four years: they will be modified, customized and updated for each Local Network, based upon the collected data, or whenever a new factor requiring the model update will be necessary.

Figure 1 – An example of Local Monitoring Network. L'Aquila (Italy)

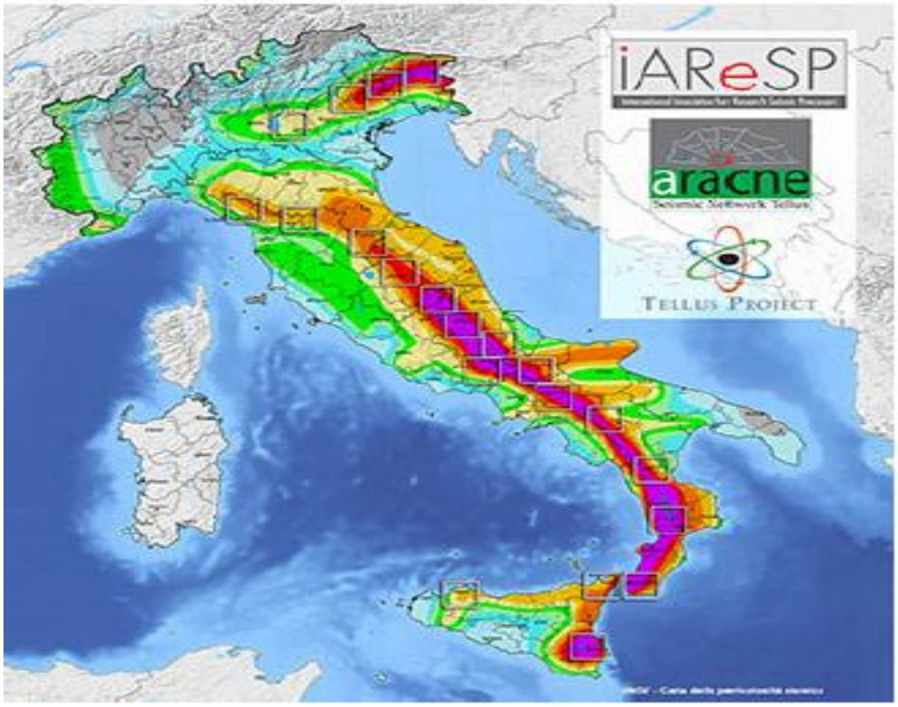

Figure 2 – The aracne network, Tellus Project.

Figure 3 – A radon measurement device for the Tellus Project.

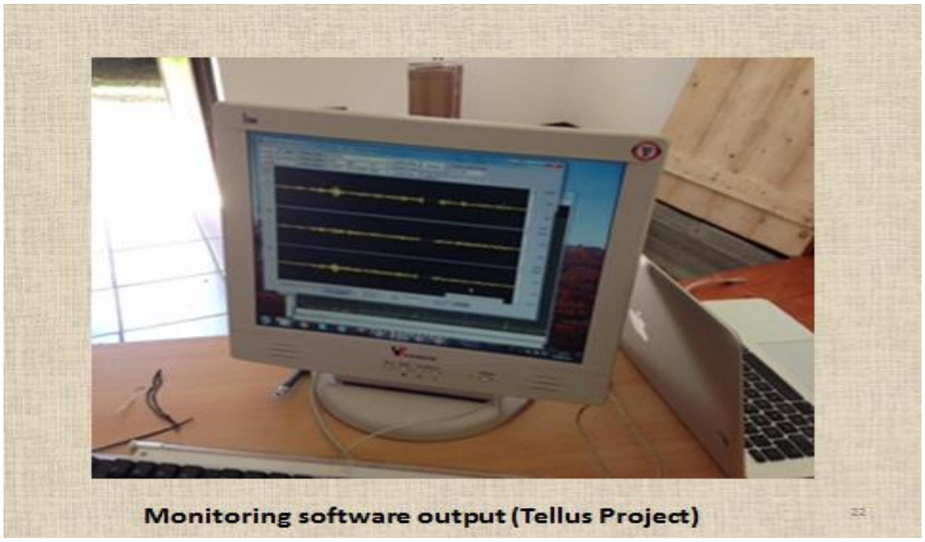

Figure 4 – Monitoring software output, Tellus Project

CONCLUSIONS

The local multidisciplinary networks will be part of the "Seismic Network Arachne Tellus" (SNAT) which will handle all the data of each Local Network. See Figure 2.
A wider approach to the Radon precursor method has been proposed, based on results from a network of several multiple, ground monitoring stations.
The intensities of the Radon emissions recorded by the network are not the only factors to be considered; Radon pulses, which are otherwise systematic in shape and time of occurrence, are analysed in real time.
Our scientific investigation has set as its ultimate goal the identification of parameters considered "seismic precursors”.
The combination of data could provide a broad geophysics framework, able to improve the current understanding of the physics of earthquakes and their processes of preparation, detectable from ground and from space.

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