GLOBAL BLUEPRINTS FOR CHANGE

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The Global Blueprints for Change contain guidance for working together to improve the capability to identify indicators of physical, social, enterprise, and environmental vulnerabilities throughout the world and to select and implement realistic solutions to reduce them towards acceptable levels.

Theme A: LIVING WITH NATURAL AND TECHNOLOGICAL HAZARDS
Topic A.7 Improving Real Time and Near Real Time Communication

" Tectonic Temporal Stress field Variations in the Seismogenic Zones Around Megacities and Urban Areas of Algeria in Relation to Plates Dynamics"

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TECTONIC TEMPORAL STRESS FIELD VARIATIONS IN THE SEINSMOGENIC ZONES AROUND MEGACITIES AND URBAN AREAS IN ALGERIA IN RELATION TO PLATE DYNAMICS

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Abstract: This Blueprint is written from the perspective and experience of Algeria. This Blueprint for Change will provide guidance to communities throughout the world that are seeking cost-effective ways to improve their capability to characterize and map in space and time the disaster agents generated by natural and environmental hazards and to develop a reliable alert system.

INTRODUCTION

The seismic phenomenon is a recurring cause of damage and loss of life in Algeria.

For example, consider the following earthquakes:

1. 1716 in Algiers, with an epicentral intensity of Io=X, which caused 20,000 deaths.
2. Blida, 1825, Io=X, 7000 deaths.
3. El Asnam, 1980, Io=IX, 2633 deaths.
4. Tipasa, 1989, Io=VIII, 22 deaths.
5. Mascara, 1994, Io=VIII, 171 deaths.

Since the beginning of the 21st century, the change in Algeria's seismicity has been monitored by means of a telemetered seismic network. In 1990, a set of 32 stations was spread along the Tellian Atlas region, the most active seismic zone in northern Algeria.

At present, we are planning to install a permanent GPS network along the Tellian Atlas (northern Algeria) especially in the recognised seismogenic zones and in the vicinity of urban areas. We are in the first phase of the project, which will be completed in 2002. We are in the process of choosing sites for the GPS receivers. The objective is to monitor the displacement of the African plate from which we can deduce the stress field. We think that the variation in the velocity and stress fields detected by the GPS survey, will enable us to locate the zones where a probable stress drop could occur, providing us with the capability for issuing an alert.

These observations must be made over a long time in order to create a reliable alert system.

STRATEGIC PLAN

Algeria, like many countries throughout the world, has experienced earthquakes and suffered from their consequences. To reduce the seismic risk and to avoid the great catastrophes that have occurred in Algeria in the past, we will work with other organizations and scientific and technical disciplines to develop and implement ongoing programmes. These programs will use the monitoring system and the new knowledge of the earthquake mechanisms and the seismotectonic characteristics of the region that will be gained from long-term monitoring.

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In Algeria, we have begun by deploying a Seismological Survey Network along the whole part of the northern of the country. This network will enable us to monitor the seismic activity along the Tellian Atlas recognised as the seat of the seismic activity. Many areas have been well studied both by seismological, geophysical and by seismotectonic studies, after the occurrence of large or moderate earthquakes, such as: El Asnam, October 10th 1980, M=7.3, Constantine, October 27th 1985, M=6.0, Tipasa-Chenoua, October 29th 1989, M=6.0, Rouina, January 19th 1992, M=5.2, Mascara, August 18th 1994, M=5.6, Algiers, September 04th 1996, M=5.7.

We believe that this monitoring capability will enable us to develop an alert system based on the variations in the velocity and stress fields. We think that it will prove to be a reliable way to prevent life loses and casualties, especially in urban areas that have then potential to become megacities.

Seismicity of Algeria: Algeria, according to its geographical position is subjected to an important seismic activity. This activity, is in relation to the collision between the African and Eurasian plates. The whole seismicity given by the NEIC and CRAAG data files shows that we have a concentration of this activity along the northern Algeria especially in the zone near the coast and define in a certain way the plate boundary zone between Africa and Eurasia from the Azores to the Aegean sea (Fig. 1).

It is clearly seen that the epicentres are located along the Tellian Atlas where occurred, during the last decades the biggest shocks such those of: El-Asnam, October 10th 1980, M=7.3, Constantine, October 27th 1985, M=6.0, Tipasa-Chenoua, October 29th 1998, M=6.0, Mascara, August 18th 1994, M=5.6 and Algiers, September 04th 1996, M=5.7. These events are located in the seismogenic zones of El Asnam, Tipasa and Algiers thrust faults and the Constantine, Mascara strike-slip faults.

Unfortunately, the seismic crises experienced in Algeria, have generated thousands of life looses, and injured. For, just the case of El Asnam earthquake the number of deaths was 2633, and 8369 others were injured. These official statistics were dramatic so that a serious take in charge must be engaged in order to avoid such catastrophes. We must keep in mind that nearly all the earthquakes that shacked Algeria occurred in or around the big cities. Because of great population concentration in that areas the danger of great catastrophe is permanent. When reading the Algerian catalogue and looking to the map of maximum observed intensities (Fig. 2) we can see that all the northern Algeria is characterised by many zone of high seismic risk.

Seismogenic Zones in Algeria: The map of maximum observed intensities of Algeria shows clearly that the seismogenic zones are concentrated along the Tellian Atlas of Algeria. These zones (Oran, Mascara, El Asnam, Tipasa-Blida, Jijel, Constantine) are concentrated linearly from west to east and define a boundary between the African and Eurasian plates. After having deployed a seismological survey network and after having also installed a geodetic survey network around El Asnam faulted area, we will deploy a GPS survey network. The combination of all the data given by these networks will enable us to propose a program on which a modern alert system can be made.

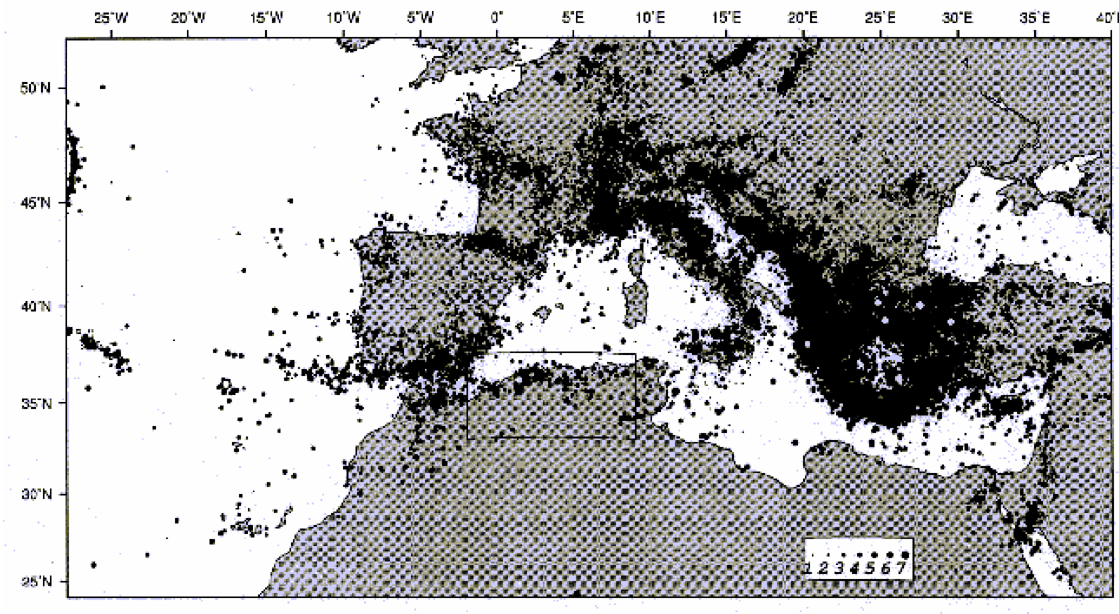

Fig. 1. Epicentre Distribution in the Mediterranean Region according to the US Geological Survey's National Earthquake Information Center and CRAAG data files

Seismological Survey In Algeria: The Seismological Survey of the seismogenic zones in Algeria has been made for a long time and up to now, by mean of traditional seismic stations. Since 1910, CRAAG has installed many stations to monitor the seismicity. Our present seismic station network is composed of 28 telemetred short period (1Hz) stations, 04 regional three component stations and 04 autonom long-mean- period stations and 02 broad band stations belonging to MedNet, and Geoscope networks. In the near future we plan to install 10 additional stations. This expanded and modernized network will enable us to perform a continuous survey of the seismic activity in order to enhance as well as possible the precision of the epicentre localisation. Another goal of this network is to detect any abnormal activity which can be considered as sign of an eventual seismic crisis, the *Algerian Telemetred Seismological Network* has experienced such case with the Rouina earthquake of January 19th 1992, M=5.2, which is the good example (Bezzeghoud et al., 1994).

A geodetic network has been installed around the Oued Fodda fault to monitor the crustal deformation in the epicentral region of the 1980 El Asnam earthquake. This network consists on a horizontal and vertical geodetic network, which were periodically surveyed from 1981 to 1992. The research program consists of repetitive geodetic measurements (levelling, triangulation and trilateration measurements). Such a network is planned for installation around other known faults in Algeria, such as the faults that generated the Constantine October 27th 1985, M= 6.0, the Tipasa October 29th 1989, M= 6.0, and the Algiers September 04th 1996, M= 5.7, earthquakes.

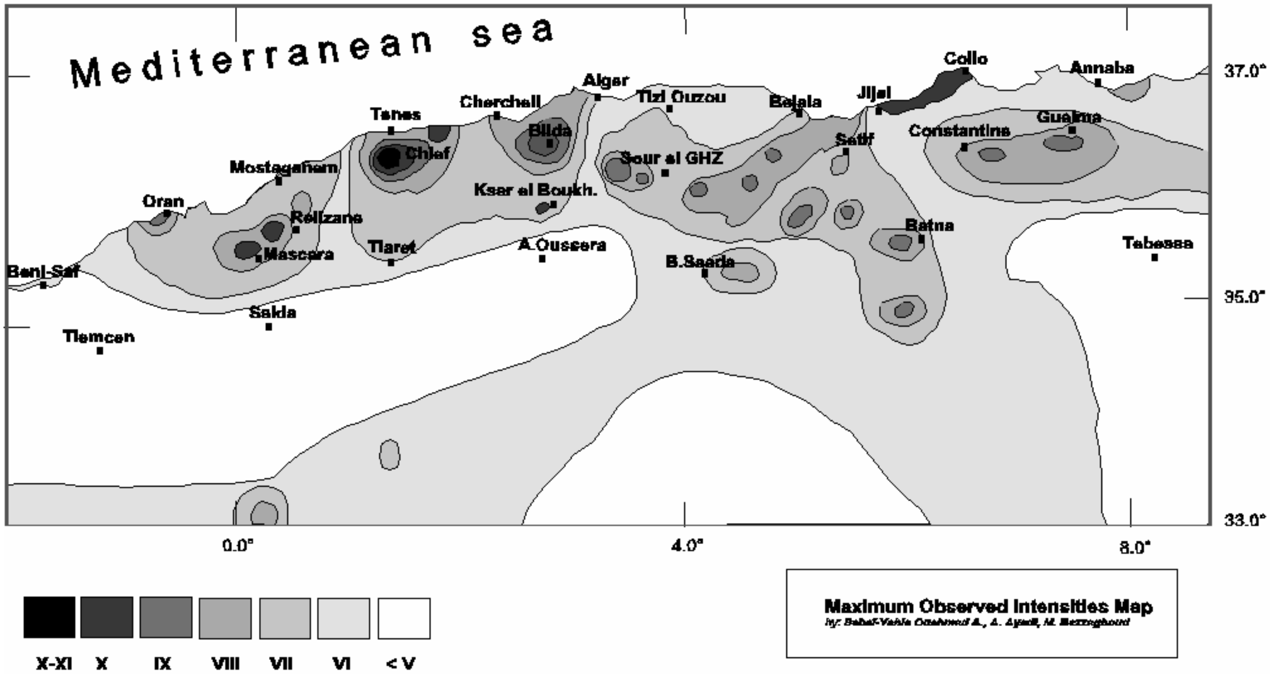

Fig. 2. Maximum Observed Intensities Map (Modified from Bezzeghoud et al., (1996))

IMPLEMENTATION PLAN

Plate Motion as a Warning System

According to many scientists, the seismic activity in Algeria is due to the African-Eurasian plate collision. This plate movement generates stress along the boundary of these two plates. When reaching the rupture level, a seismic event occurs. This is the basic idea, upon which we want to construct our project, which consist in monitoring the African plate movement towards the Eurasian one, by evaluating the velocity field. The later, will enable us to calculate the stress field along the plate boundary. Any change of this parameter in any area will enable us to predict the occurrence of stress drop that can be correlated with an eminent earthquake. Of course we have to keep in mind that ongoing calibration of the major seismogenic zones of Algeria is necessary.

We propose to use bi-frequency GPS receivers. We plan to deploy them by the beginning of year 2002, throughout northern Algeria, in or adjacent to seismogenic zones identified by previous studies. The sites, which have been chosen to receive the GPS receivers, are located relative to Alger-Bouzaréah, a permanent and fixed station. A geodetic reference point is available on the site and belongs to the *" Algerian State Geodetic Network "* This point will enable us to calibrate our new network. Twenty-four other points are proposed to be surveyed twice a year (during the first phase) along the Algerian coast with an interval distance of 50 km. This network will be connected to the network present in the south of Europe (France, Spain, and Italy) and with the closest IGS networks. We expect to have a precision of about a millimetre by combining our data with those of IGS networks.

Recently, Bezzeghoud et al., 1997 on the basis of scalar seismic moment release for earthquakes (M≥4.0), has estimated the average slip rate in the western part of the northern Algeria. The horizontal shortening slip is U_h =7.6 mm/yr. This result is comparable with those evaluated by McKenzie (1972, Uh=9 mm/yr), Minster & Jordan (1978, Uh= 11.4mm/yr), Buforn et al., (1988, Uh=11.5mm/yr). By combining this value of horizontal slip rate with what we observe in the El Asnam region we found a value of 10.9 mm/yr, represented by the sum of a 7.6 mm/yr given for the western Algeria and a 3.3 mm/yr which represent the aseismic (deduced from geodetic survey) slip.

Past and Recent Studies in the Region: The recent/present motion trend of the African plate with respect to Eurasian plate is characterised by a convergence trend in the NW to NNW direction in the Ibero-Maghrebian region confirmed by geological and seismic shortening pattern (see, e.g.; King and Vista-Finzi, 1981; Philip and Meghraoui, 1983; Buforn et al., 1988). According to Mantovani et al., 1997 the African plate would have a NE to NNE motion direction by regards to post Tortonian deformation pattern in the Central Mediterranean area. After Udias (1982) map we can observe that the convergence of the African to the Eurasian plate has a NNW to NW direction. This is confirmed also by Vegas (1991) who show a NNW displacement of the African plate to Eurasia. Unfortunately, till now the plate boundary is not defined with precision. The absence of observations points along the northern Africa constitute the main problem in the boundary plate determination. That is the reason why we propose to install a GPS survey network in order to: first of all, determine the plate boundary and in a second phase to survey the velocity field along this boundary to initiate an alert system for earthquake occurrence.

RECOMMENDATIONS

We recommend that the effort to develop an alert system for Algeria be accelerated. In the case of Algeria, (and other developing countries in the Mediterranean Region) an alert system is very important for at least three reasons:

First, in the case of major historic earthquakes such those of Algiers 1365 and 1716 or that of Oran 1790, a catastrophe could not be avoided because we did not have the knowledge of th4e seismicity and the technology to monitor it, but we do now.

The second is that the major part of Algerian population and infrastructure are concentrated in and around seismogenic areas, where the seismic hazard and the seismic risk are high. The principal economic and industrial sectors of Algeria are all located in and around the big cities where the population density per kilometre square is very high because of their location on/or in the vicinity of the plates boundary. The railway network and the highway system are an example. Both are concentrated on the most dangerous part of the country

The third is that we have a moral and technical obligation to develop a reliable alert system program that can be used to protect people and property.

Of course we have not the pretension that we will succeed to make a perfect alert system in the next few years, but we hope that our studies and the data we will collect, will enable us to conceive a reliable alert system in the very near future.

REFERENCES

Benhallou H., M. Bezzeghoud, D. Dimitrov and K. Lammali. 1990. Seismological and Geodetic Networks. Proceedings, I workshop on MedNet the broad-band seismic network for the Mediterranean, pp. 495-501. Sept. 10-14, 1990, CCSEM, Erice, Italy.

Bezzeghoud M., A. Ayadi, A. Sebai and H. Benhallou. 1994. Seismogenic zone survey by Algerian telemetred Seismological Network. Case study of Rouina earthquake, 19 January 1994. Phys. Earth Planet. Inter. 84, 235-246.

Bezzeghoud M., A. Ayadi, A. Sebai, A. Ait Messaoud, A. Mokrane, & H. Benhallou. 1996. Seismicity of Algeria between 1365 and 1989: Map of maximum observed intensities (MOI), Avances en Geophysica y Geodesia, I, 107-114, IGN, Madrid.

Bezzeghoud M;, D. Dimitrov, J.C. Ruegg and K. Lammali. 1994. Faulting mecanism of the 1954 and 1980 earthquakes from vertical movements modelling. Proceedings, 1st Turkish international symposium on deformation. 573-584. Sept. 5-9 1994, Istanbul, Turkey.

Dimitrov D., K. Lammali, A. Khalfoun and H. Benhallou. 1991. Post-seismic movements from 1981 to 1988 on the El Asnam thrust fault (Algeria). Publication I.G.N. on Seismicity, seismotectonics and seismic risk of the Ibero-Maghrebian region. série Monografia N° 8, pp. 241-254.

Kaniuth K., H. Drewes, H. Tremel, K. Stuber, S. Zerbini, L. Pezzoli and G. Corrado. 1994. Crustal deformation in the Calabrian arc area from five years of GPS measurements. Proceedings, 1st Turkish international symposium on deformation, pp. 781-790. Sept. 5-9 1994, Istanbul, Turkey.

Lammali K., D. Dimitrov, M. Bezzeghoud, F. Ousadou and H. Benhallou. 1994. Vertical movements survey around the El-Asnam thrust fault: A review. Proceedings, 1st Turkish international symposium on deformation. Pp. 336- 345. Sept. 5-9 1994, Istanbul, Turkey.

Lammali K. M. Bezzeghoud, F; Ousadou, D. Dimitrov and H. Benhallou. 1997. Postseismic deformation at El Asnam (Algeria) in the seismotectonic context of northwestern Algeria.. Geophys. J. Int. 129, 597-612.

Mantovani E., D. Albarello, C. Tamburelli, D. Babbucci and M. Viti. 1997. Plate convergence, crustal delamination, extrusion tectonics and minimisation of shortening work as main controlling factors of the recent Mediterranean deformation pattern. Annali di Geofisica, Vol. XL, N3, pp. 611-643. June 1997.

Vegas R., 1991. Present-day geodynamics of the Ibero-Maghrebian Region. Publication I.G.N. on Seismicity, seismotectonics and seismic risk of the Ibero-Maghrebian region. série Monografia N° 8, pp. 193-203.

Udias, A., 1982. Seismicity and seismotectonic stress field in the Alpine-Mediterranean region. Am. Geophys. Union, Geodynamics series, Vol. 7, pp. 75-82 (1982).