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NARPIMED Project:

Natural Risk Prevention in Mediterranean Countries.

Natural Risks in Morocco

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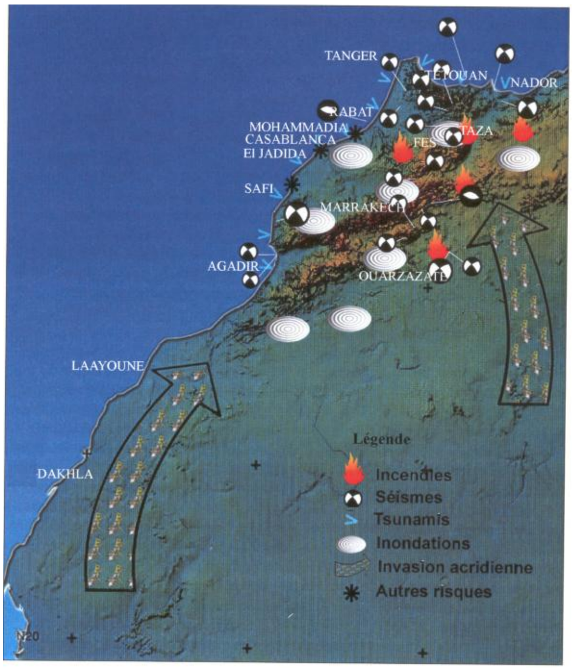
I-Introduction

Morocco is facing miscellaneous natural hazards presenting all serious risk. The demographic growth, the economical development, urban expansion and the vulnerable infrastructure increase more this risk and make difficult any classical disaster mitigation. To develop adequate prevention planning strategy, decision makers need precise and integrated information on the different natural risk assessments based on deep coordinated scientific studies.

Providing fundamental means for such research and close collaboration with all partners (universities, research institutions, civil and military protection and administrative institutions) should guide officials at local, regional and national levels to formulate development strategies aiming to reduce the impact of disasters.

In this report, among all natural risks presented graphically in the figure beside, a summarized technical study of Seismic, Floods and Fires risks is given as well as a short description of Civil Protection attribution.



II-The Seismic Risk Problem in Morocco

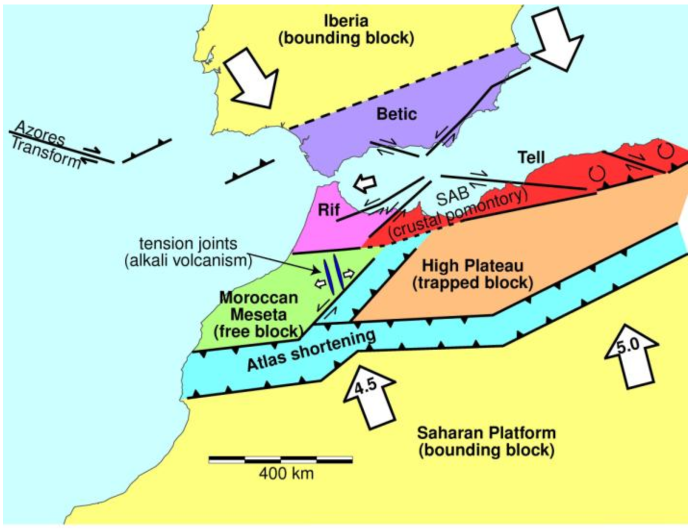


Plate motions (large arrows) are based on NUVEL-1 (Demets et al., 1990)

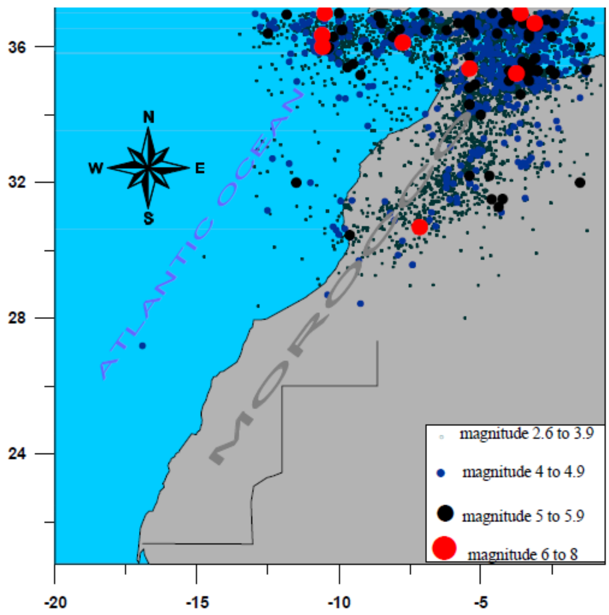
Located in the westernmost part of Alpine belt, Morocco is belonging to the converging African and Eurasian plate's boundary. This particular tectonic situation is expressed by a moderate seismic activity that generates one of the most important natural hazards. This potential source of seismic activity is related to the 5 to 6mm/yr. NNW-SSE trending plate convergence of Africa towards Eurasia [*DeMets et al., 1990; Fadil et al. 2006; Tahayt et al., 2008*].

During the last 1000 years, Morocco experienced several destructive earthquakes that maximum intensity exceeded IX in the MSK scale [*El Mrabet, 2005*]. We can cite as examples ▶ the northern Morocco 22nd September 1522 earthquake with maximum epicentral intensity Io of IX, ▶ the Fez 11th May 1624 earthquake with Io=X; ▶ the Lisbon 1755 earthquake with Io=XI which affected dramatically many cities in Morocco and Algeria; ▶ the 29th February 1960 Agadir catastrophic earthquake (Mw=5.7) that Caused the loss of about 12.000 lives, injured at least 12.000 and thousands of survivors were trapped under the rubble of the structures; and ▶ the 24th February 2004 Alhoceima earthquake (Mw=6.2) that caused about 629 deaths and same number of injured people.

The seismicity map shows three principal seismogenic areas:

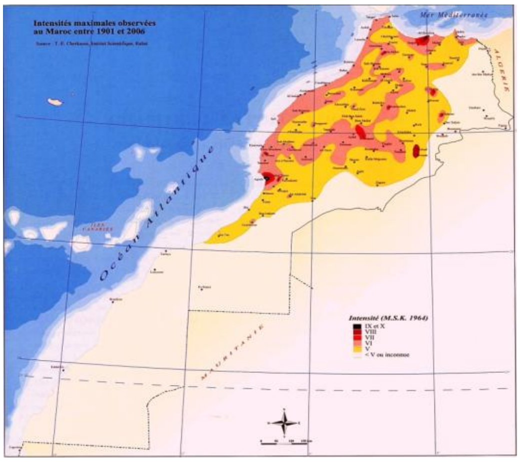
1-**The Atlasic area**: where the activity is mainly located in the medium and central high atlas chains. It is characterized by the presence of kilometric crustal mio-pliocene and quaternary reverses faults with strike-slip component associated with folds (*Ait Brahim, 1991; Fida M. and T-E. Cherkaoui (1991); Ait Brahim et al. 2002*). To this area belong several large earthquakes such the Agadir, 29th February 1960 which destroyed the major part of the city (Io~IX-X); the Azilal earthquake on 14/10/1936, with magnitude M_W 5.2 (Io=VII), and the Taroudant earthquake on 20/04/1955, with magnitude Io=VII, M_W 5.2 (*El Mrabet et al., 1991; Levret, 1991; Moratti, 2003; El Mrabet, 2005*)

2- **The Rif-Alboran Sea area**: The activity in this area is characterized by sequences distributed on three main epicentral clusters: a) The Nador-Melilla cluster where the Melilla earthquake sequence for example occurred on 22/12/1999, M_W 5.7 (Io = VII) [*El Mrabet, 2005*]. B) The Alhoceima zone: This zone contains the southern part of the Alboran Sea and the central Rif including the Nekor (NE-SW) and Jebha (ENE-WSW) left strike slip faults. This zone is subjected to the influence of the faults in "crustal" scale of the Alboran ridges, which corresponds to a structure of kilometric scale (fold fault) which absorbed a great part of the Africa-Europe convergence (*Ait Brahim, 2002; Azzouzi et al., 2005*). In this zone occurred the 26/05/1994, M_W 6.7, and the destructive 24/02/2004, M_S 6.2, Al Hoceima earthquakes. c) The western Rif zone: This zone includes the western Rif, its overlapping boundary on the Gharb basin and the Gibraltar straight. It is the seat of significant earthquakes like that of the 27/12/1722, with magnitude M_W 6.9, the 21/01/1909, M_W 6.4 (IX), and that of Tangiers on 12/04/1773, with magnitude M_W 6.7 (I_O = VII) [*El Mrabet, 2005*]. The focal mechanism of the 15/03/1964 earthquake, with magnitude m_b 6.2, gave a reverse fault plane with ENE-WSW orientation. d) The west Alboran zone: This zone corresponds to the Western part of the Alboran Sea characterized by intermediate depth earthquakes. The Ms 5.2 (Mw 4.0) earthquake on 07/08/1975 was characterized by reverse with strike slip component focal mechanism (*Coca & Buforn, 1994*).



3- **The Atlantic area**: This area is located in the Atlantic at the boundary of Iberian and African plates extending from the azores to the Gulf of Cadiz including the western part of Gloria and Gorringe transforming faults. Eastward, this contact is strongly affected by transversal faults. These faults are responsible of the 01/11/1755 Lisbon earthquake, with macroseismic magnitude M_W 8.7. This event involved significant damage on the Moroccan territory, and a tsunami on the Atlantic coast. It was followed by many aftershocks, including that of November 18, the most strongly felt in the North of Morocco (Tangier, Tétouan). This zone also generated (28/02/1969) a strong earthquake with magnitude *Mw* 7.9 (*Zitellini et al., 2001; Gracia et al., 2003*).

The focal mechanisms (e.g. Harvard CMT) of recent earthquakes display consistent WNW-ESE and NW-SE trending respectively reverse and right lateral strike slip in the Gulf of Cadiz ([*Buforn, E. and Udias A., 1991; Buforn et al., 1995*]), NE-SW trending left lateral strike slip in the Rif region (Alhoceima 26 May 1994 (Mw 6.0) and 28 Feb. 2004 (Mw 6.3) earthquakes; [*Calvert et al., 1997; Buforn et al., 1997; Bezzeghoud & Buforn, 1999; Biggs et al., 2006*]). Shortening of the Moroccan Atlas has accommodated 17% to 45% of the total African-Eurasian plate convergence since the early Miocene, whereas the majority of the plate convergence is accommodated in the Rif-Betic-Alboran region [*F. Gomez et al., 2000*].



Maximum Observed Intensity in Morocco from 1901 to 2006 (T.E Cherkaoui 2002 In « Fenêtre sur le Territoire Marocain. » Ministère de l'Aménagement du Territoire, de l'Urbanisme, de l'Habitat et de l'Environnement ; Direction de l'Aménagement du Territoire)

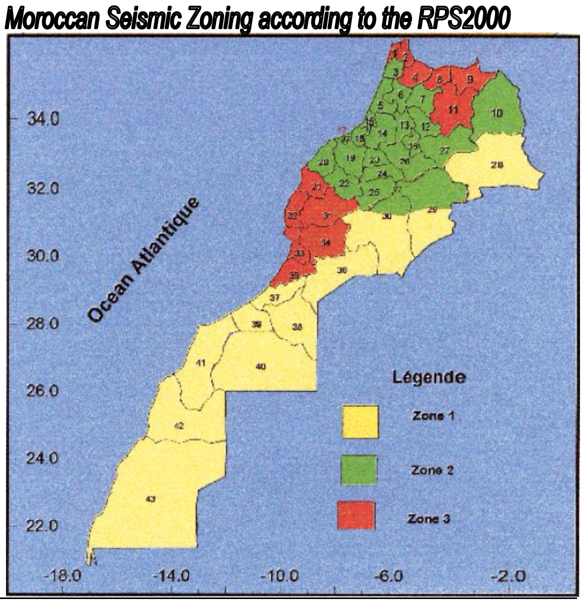
A quick analysis of the ratio between the damage caused by earthquakes and the energy associated to them shows that it is much higher when compared with other countries as Japan or USA. This difference can be explained by 1) the elevated vulnerability of the Moroccan habitat in the rural zones, 2) the degradation of many urban areas dominated by illegal buildings particularly widespread in suburbs of big cities which crowed quickly and anarchically, and 3) difficulties in the application of the seismic risk reduction policies.

The 2004th Alhoceima earthquake triggered a serious intention to face the seismic risk at all levels.

3-National Institutions:

The seismic monitoring is performed by two national institutions: **1)** The "Centre National de la Recherche Scientifique et Technique" ***CNRST*** in Rabat controlling a telemetric short period network and few accelerographes installed in dams. **2)** The "Institut Scientifique" ***IS*** belonging to Mohamed Vth University in Rabat controlling an old analogical short period network. Both institutions are nowadays updating their networks with new broad-band seismic stations within national and international projects contexts.

4- Moroccan Seismic Codes



The first Moroccan seismic code was formulated just after the Agadir 1960 earthquake and called "*Normes d'Agadir 1960*" (*NA1960*). It was applied in the city during the reconstruction period.

A new regulation, called " RPS on 2000 " was ruled on by the decree n°2-02-177 of February 22nd, 2002. The same decree founded the *National Committee of Seismic Engineering (NCSE)* which objectives are:

- Proposition and recommendation to improve the seismic zonation and building codes
- Improving the urban planning through seismic microzonation

The RPS 2000 divides the whole national territory into 3 zones of seismicity and is applied since September 23rd, 2002 to the new constructions exceeding 50 m^2 of surface and to the existing buildings that must undergo important modifications. It covers only the structures in reinforced and steel concrete, and excludes the traditional constructions which abound in rural areas and undergo the most serious damages during earthquakes as it was observed after the 2004 Alhoceima Earthquake.

During 2008, the The Ministry of Housing, Town Planning and Development through the *NCSE* promotes the new version of RPS 2000. According to *NCSE*, the revision is justified by diverse reasons. *First*, different users (engineering consulting firms and control) showed difficulties for the suitable application of the various prescriptions of the regulation. *Second*, there is no reliable and validated software for the conception and works' sizing in accordance with the RPS 2000. *Finally*, the seismic data which were used for the RPS 2000 seismic risk determination covered only the period before 1980.

As general precautions to be taken according to the RPS 2000 we can specify: *1)* any building's construction must be forbidden in the neighborhood of the active or passive faults; *2)* ground foundation studies are compulsory and applied in the same way as in high and low seismic risk situations. They have to allow in particular the classification of the site with regard to the various types prescribed by the code; *3)* a particular attention must be given in the conditions of sites at risk such as ► the presence of unconsolidated or reconstituted ground, ► the presence of near water table which may cause liquefaction during earthquake, ► the risk of landslide.

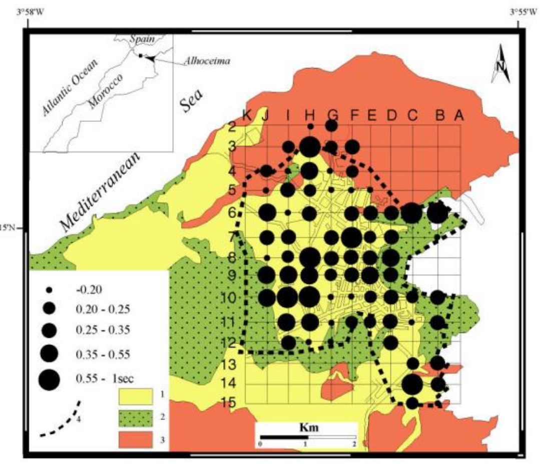
The policy followed by the government to guarantee the RPS 2000 application was based on several meetings, broadcasting of documents to raise population awareness, implication of all operators such professionals, engineers, architects, promoters and entrepreneurs of the construction sector.

Many efforts, however still to be done to improve the social implication and the level of preparedness through:

- Adequate and constant information to population,
- School education and technical training of experts,
- Development and improvement of emergency management and immediate intervention after catastrophic earthquakes, (The panic observed during the catastrophic 2004th Alhoceima event showed how weak was the experience and preparedness of civil protection).

5- Seismic Microzonation:

Earthquake hazard zonation for urban areas is the first and most important step towards a seismic risk analysis and mitigation strategy in densely populated regions. Recently, in Alhoceima region, an experimental seismic microzoning is curried up in all projected areas for urbanization to obtain a good understanding of the local subsurface conditions. In the figure, a geographical distribution of predominant period determined by microtremor measurements in Alhoceima city is presented. These results obtained in 1999 were compared with damages distribution related to the 2004 Alhoceima earthquake. There was a good agreement with predicted ground amplification. Such study is being performed in Alhoceima region at a large-scale.



Soil features of the Alhoceima area and predominant periods. 1) Sandstone, soft soil; 2)Limestone and schistes, 3) Limestone, hard rock; 4) Urban area

III- Floods Risk in Morocco

The droughts in Moroccan climatic history are frequent and caused even famines. Morocco undergoes really the effects of a climatic change and it is suitable to study the consequences. The droughts are henceforth longer, more frequent and they succeed themselves. They are sometimes interrupted by abundant rainy episodes that originate dreadful floods.

During the recent history, Morocco suffered from several catastrophic floods. We can mention the one that devastated Sefrou on 25/9/1950 when the city was flooded with 6m water's high causing about one hundred victims.

- The Moulouya river floods occurred on May 23 1963 were with an extreme violence and took the left shore foundation of Mohammed V dam (the floods had a debit of 7200 m3/s and a volume of 570 millions of m3 which is the equivalent of the withholding capacity).
- The floods that ravaged the Valley of Ziz on 5/11/1965 had left 25000 homeless which accelerated the realization of the Hassan Addakhil's dam.
- The violent floods of the Sebou River each two years made the Gharb plain suffer consequences.
- More recently, the collective memory will keep forever the disastrous events of the Ourika in 1995, of El Hajeb in 1997, of Tetoaun 2001, of Settat and Mohammedia in 2002 and of Tan Tan, Nador, Al Hoceima and Khénifra in 2003; Fnideq, Tanger, Ouarzazate, Nador, the Gharb, 2008. The Figure shows the administrative geographical distribution of flooded areas.

Three decades dominated by heavy drought made the formerly flowing rivers dry and encouraged rural citizens crowd and constructing over river beds. The proliferation of vulnerable constructions over flooding spaces put in risk the life of innocent citizens.

The flood phenomenon comes back again to recall the authorities their responsibilities to guarantee the protection of the citizens that becomes more and more vulnerable. Demographic growth, economical advancement and urban expansion, agricultural, industrial and tourist development induce growing vulnerable zones.

The worsening of the extreme phenomena (drought and raw) following the climatic changes seems to be behind the observed localized, quick and violent floods.

The big rivers of Morocco such as Moulouya, Sebou, Oum Er Rbia, Tensift, Sous, Drâa and Ziz have their versant basins surpassing the 10 000 km^2 of surface. During flood periods, their alluvial plains are covered slowly by water within large ranges giving relatively long alarm delay. Nevertheless, several technical, economical and social challenges make them generally insufficient. The coastal rivers, having small to medium versant basins are characterized by quick floods and very short response time to the rain. The alarm delays are hence reduced and, sometimes torrential floods produce important damages like the ones observed during the floods of Oued Fnideq (northern Morocco) of 2008. Small other rivers all alongside Morocco can generate the same type of torrential floods threatening towns and cities such as Marrakesh, Mohammedia, Settat, Berrechid, Beni-Mellal, Errachidia, Oujda Tangier …etc.

Official Institutions

The State Secretariat of Water (SSW), official organism in charge of floods monitoring, adopts a methodical gait to reach the objective of floods risk mitigation at national level. To ensure the protection of vulnerable zones, the SSW bases its mitigation approach on Prevention Planning and Monitoring. Several hydrologic stations were newly installed on the principal rivers and others portables were obtained in sight of eventual interventions. Risk maps were elaborated and put at the disposal of national and local authorities. Other special measures of prevention were taken in the case of the valley of Ourika for example by installing an alarm system that allows launching the alarm system and proceed to the evacuation of population at before floods.

Prevention Strategy

The National Plan of Protection against Floods (PNF) allowed identifying 390 priority centers of which the treatment will be realized before 2020. This PNF's ambitious plan consists on the constructions of several protection pieces of work (dams, channels...etc.), basin versant planning, regulation, organization and consciousness-raising.

IV- Fires Risk in Morocco

With a rate of almost 1 million ha burned per year, fire is one of the most destructive natural disasters of the Mediterranean environment.

The Moroccan average of 2938 ha on fire stays below the Mediterranean average indeed, but their economical and social effects are big as the forestation rate is very low (8%) and the climate droughtbnbecoming more and more accented.

Fires are in 95% unknown origins which make it difficult to put up an adequate preventive strategy.

The most affects provinces are located in northern Morocco: Chefchaouen, Tetouan, Larache, Tangiers, Taza, Taounate, Kenitre and Khemisset.

Official Institution

The ***High Commissionership for water and Fight against desertification*** **HC** (belonging to the Prime Ministry) made up a plan of fires management strategy called **PDI** "*Plan Directeur des Incendies de Forets*". It is based on 5 sections:

1- Equipment and infrastructure

2- Cooperation with potential partners

3- Fighting operational plan

4- Formation

5- Popular increased awareness.

Prevention Strategy

The governmental action through the HC includes 3 main aspects:

a- prevention: solving the problem of fire in their origin

b- Monitoring: consists on earliest detection of fires and giving alarms within small delays after fire sitting-of

c- Fighting with an anticipative approach to control the fire in their beginning stage and to limit the extension. 3 levels of intervention are considered in this last point according to engraving situation:

1- HC and Civil Protection

2- Royale Gendarmerie aircrafts

3- Military intervention with C130 planes.

V- Civil Protection

Instituted basically by the Dahir (Real Decree) of April 30th 1955, the decree of December 15th, 1997 gives the attributions of CP as Direction of Civil Protection belonging to the Ministry of Interior. Its action's field is the protection and the defense of the civil population and properties in any circumstances.

The Direction of Civil Protection has the responsibility of the following missions:

- Organize, animate and coordinate the implementation of the measures of protection and help of the persons and the properties during disastrous events;
- Insure the protection of the population and the national heritage saving during circumstances recovering the civil defense;
- Organize and insure the administrative and technical management of the Services of help and Fire fighting;
- Prepare and begin any action share of fight of Plagues of the Desert Locust.

In Morocco, the Centers of decision of CP services are articulated as follows:

- At the governmental level, the general policy of CP falls to the Prime Minister.
- In the level of the Central Administration, the execution of this general policy returns to the Ministry of Interior by the adoption of protective measures and the coordination of National, Local authorities, Public and private Institution's help means.
- At regional level, 16 regional commands of CP services were recently created to exercise as technical and operational adviser with Walis of regions and Governors of Prefectures and Provinces. The regional commands are in charge of staying up the security of the citizens and the protection of their goods in any circumstances under the authority of the Governor of the Prefecture or the Province, the administrative centre of the region.