Mitigating The Impacts of Natural Risks in Africa

23-26 October 2017, Cairo, Egypt

Seismicity of Algeria case study of the El Asnam (1980, Ms 7.3) and Zemmouri (2003, Mw 6.8) strong earthquakes

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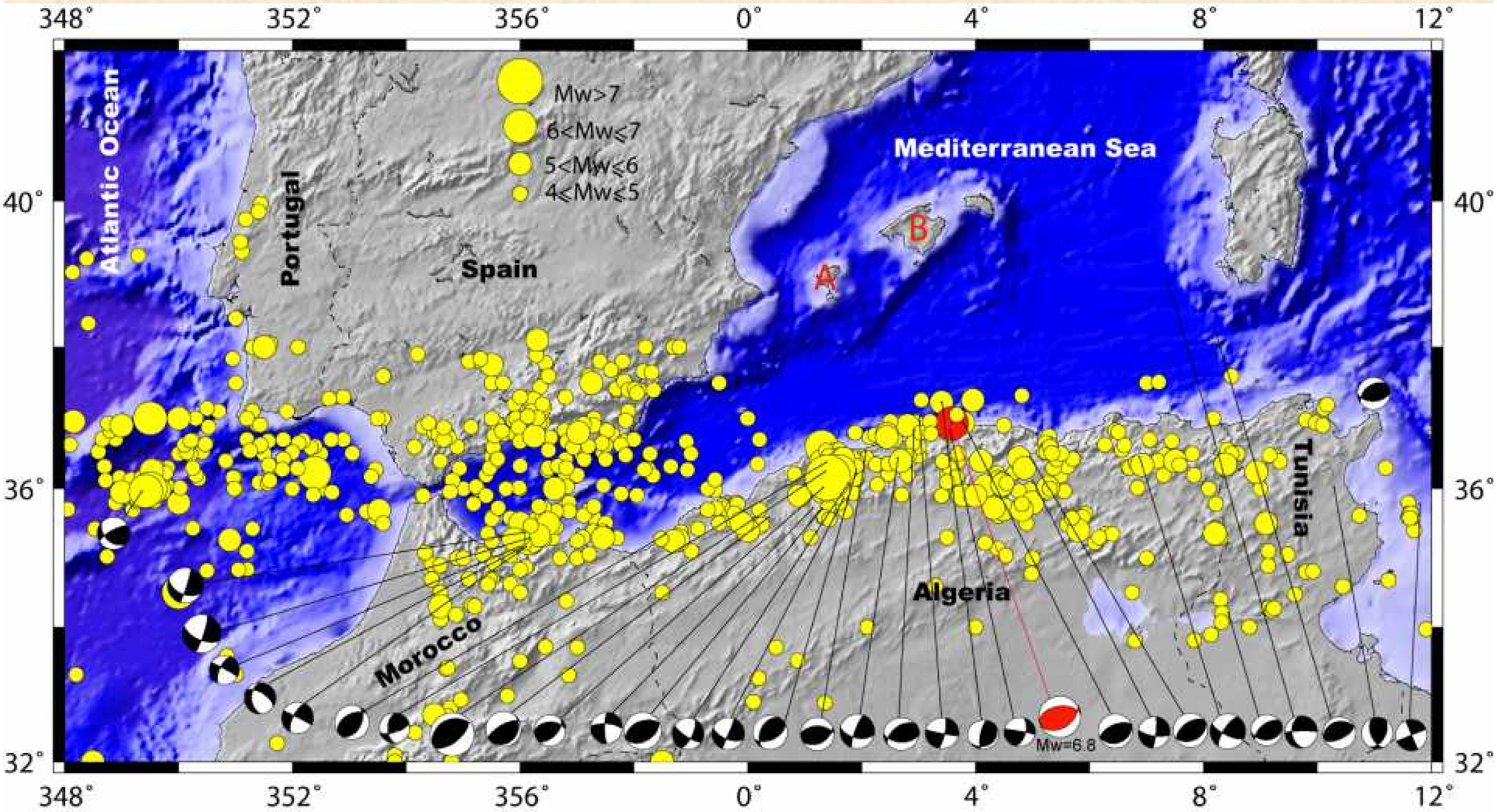
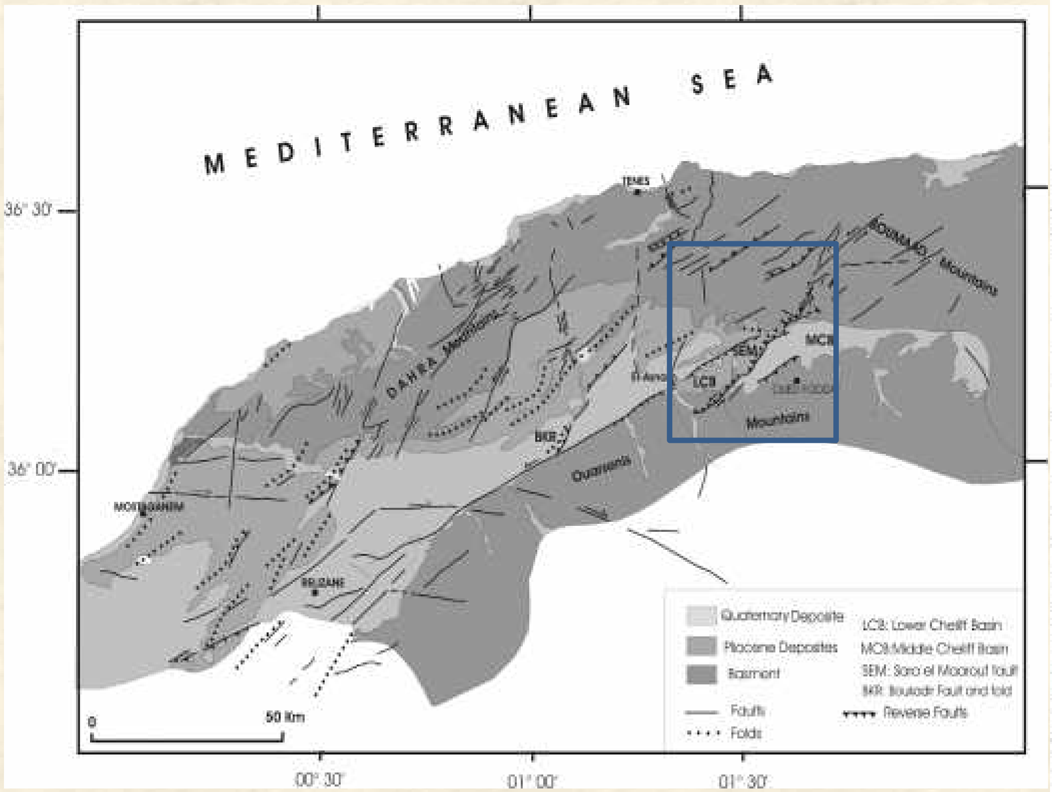
Seismicity Map of Algeria

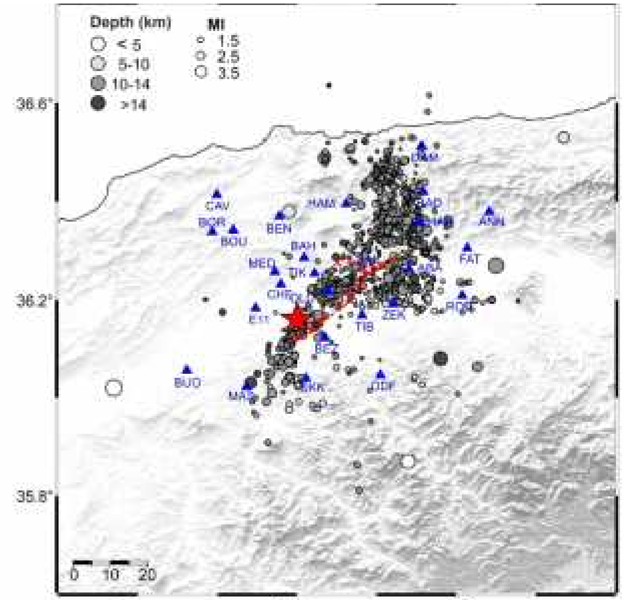
The seismicity of Algeria is associated with the Africa-Eurasia plate boundary starting from the Azores triple junction to Tunisia. The area is characterized by predominant reverse mechanism especially in Tell Atlas of Algeria and by strike-slip faulting in the Rif Atlas (Morocco) and eastern Algeria and Atlas of Tunisia

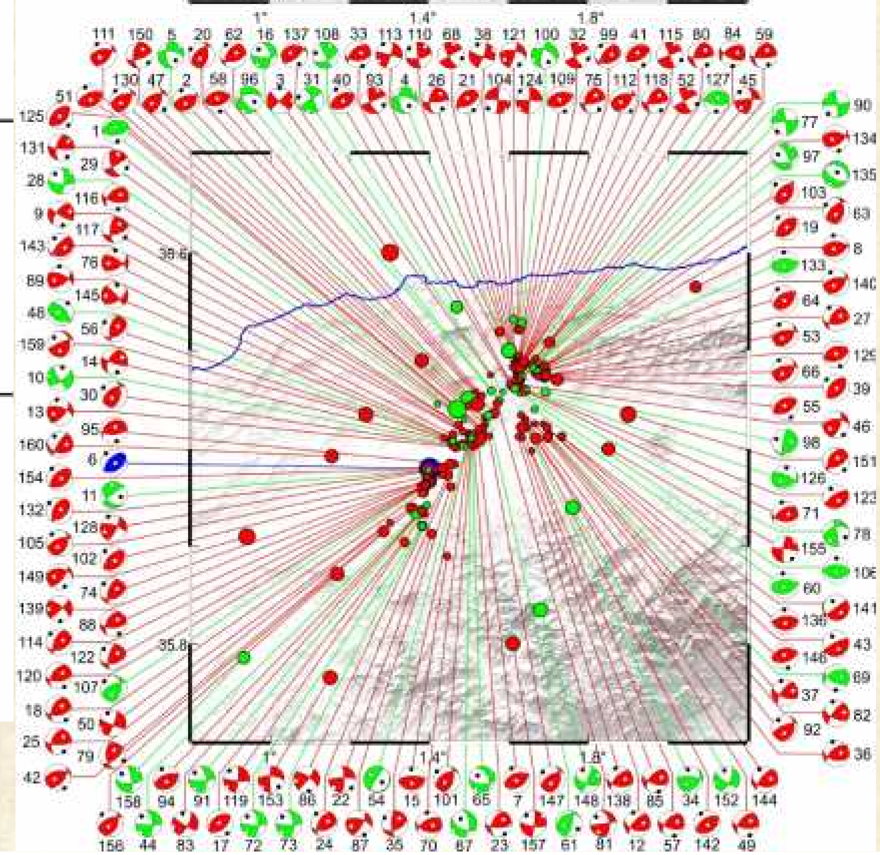


El Asnam earthquake of October 10th 1980, Ms 7.3

The region of El Asnam was struck by a strong EQ On October 10th 1980 Ms7.3. It was the largest event the Tell Atlas experienced since the beginning of the XX century. Generating significant surface faulting and huge damage and casualties.







El Asnam earthquake (10/10/1980, Mw 7.3)
36 km of thrust faulting

<table>
<tr><th colspan="6">CLASS OF VULNERABILITY</th><th rowspan="3">EARTHQUAKE / SITE

El Asnam
Algeria 1980</th><th colspan="5">GRADE OF DAMAGE</th></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td></td><td>●</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>●</td></tr>
<tr><td colspan="6">TYPE OF STRUCTURE:</td><td colspan="6">RC frame and brick infill walls</td></tr>
</table>

Comment:

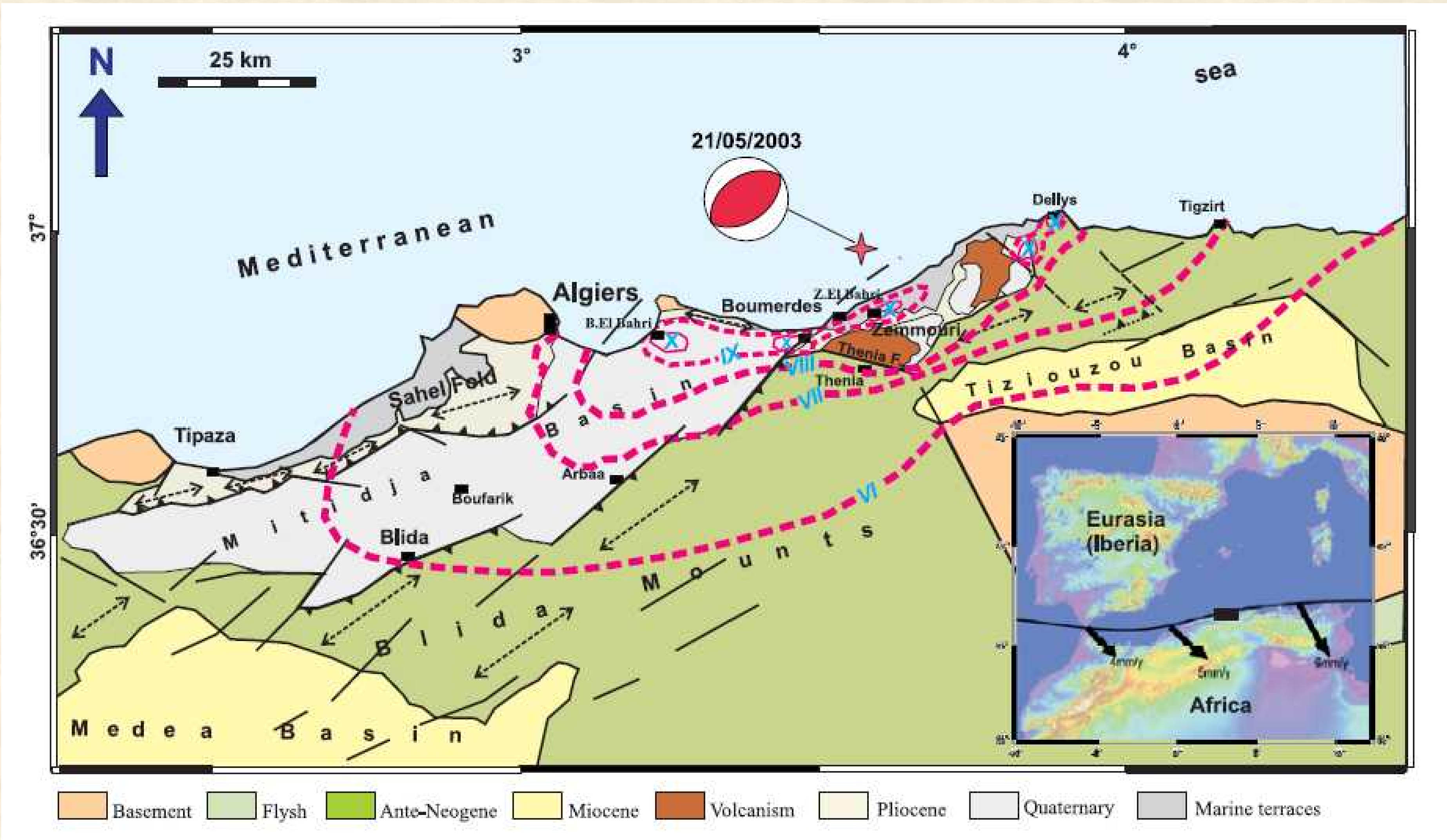
Clear situation with respect to grade of damage.
The structure was designed against seismic loads (low level of ASD), but there are such serious defects within the design (weak or soft ground floor) that the vulnerability class has to be reduced. Vulnerability class C seems to be appropriate.

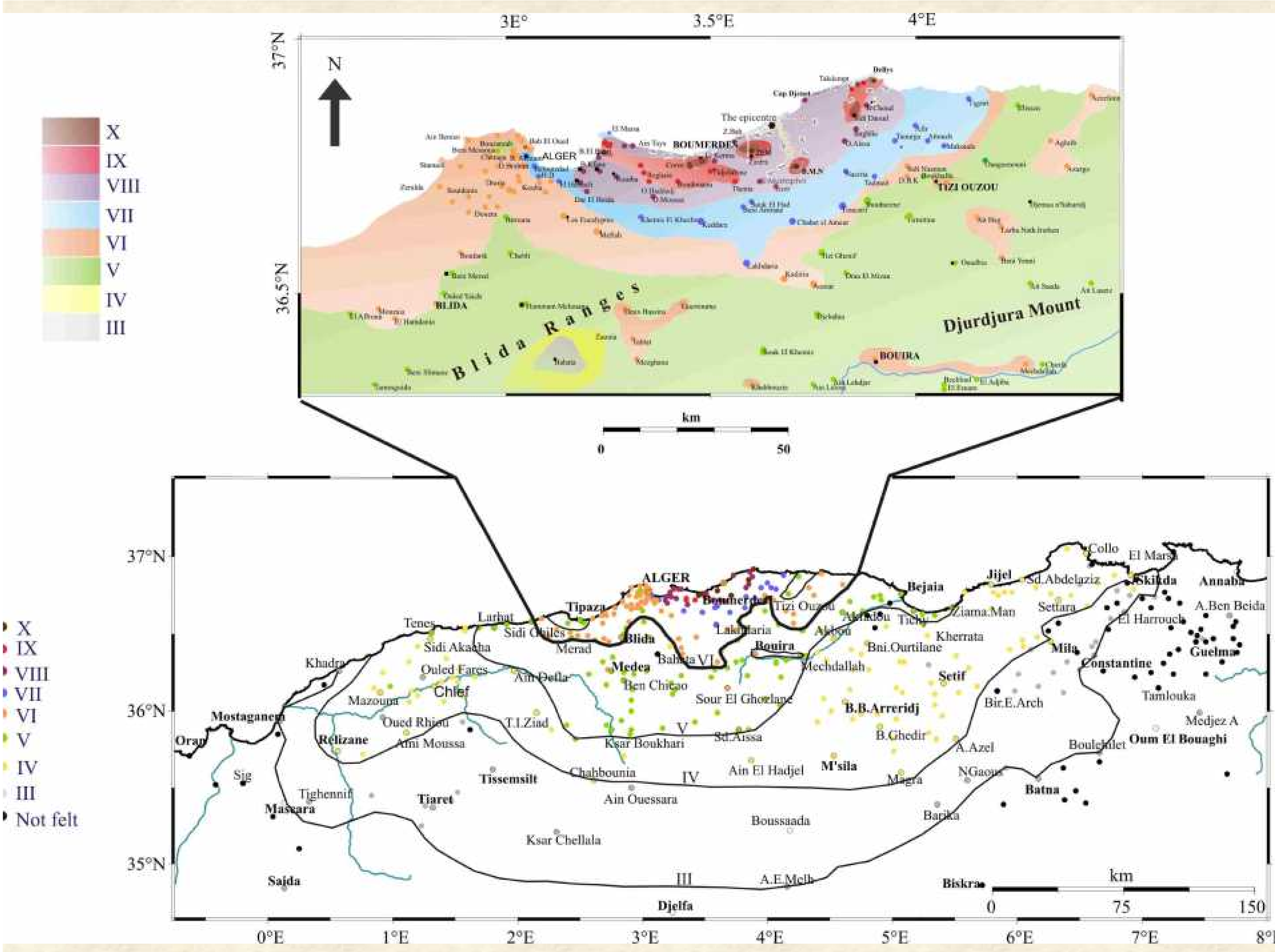
Heavy damage on buildings (soft ground level)

Deformation on the railroad at El Asnam rupture zone

Zemmouri EQ of May 21st 2003, Mw6.8

The Zemmouri EQ on May 21st 2003, Mw6.8 on the northeastern edge of the Mitidja basin. It was the strongest event after the El Asnam October 10th 1980 Ms7.3.





3E°
3.5°E
4°E
37°N
36.5°N
N
X
IX
VIII
VII
VI
V
IV
III
ALGER
BOUMERDES
The epicentre
Dellys
Cap Djinet
TIZI OUZOU
BLIDA
BOUIRA
Blida Ranges
Djurdjura Mount
km
0
50
37°N
36°N
35°N
0°E
1°E
2°E
3°E
4°E
5°E
6°E
7°E
8°E
X
IX
VIII
VII
VI
V
IV
III
Not felt
Oran
Mostaganem
Sig
Mascara
Saïda
Relizane
Khadra
Tenes
Larhat
Tipaza
Sidi Ghiles
Sidi Akacha
Ouled Fares
Chlef
Mazouna
Oued Rhiou
Ami Moussa
Tighennif
Tiaret
Tissemsilt
T.I.Ziad
Ain Defla
Merad
Blida
Medea
Ben Chicao
Bahata
Ksar Boukhari
Chahbounia
Ain Ouessara
Ksar Chellala
Djelfa
ALGER
Boumerdes
Tizi Ouzou
Lakhdaria
Bouira
Sour El Ghozlane
Sd.Aissa
Ain El Hadjel
M'sila
Boussaada
A.E.Melh
Mechdallah
Akbou
Bejaia
Bni.Ourtilane
Kherrata
Ziama.Man
Jijel
Sd.Abdelaziz
Setif
B.B.Arreridj
B.Ghedir
A.Azel
Magra
NGaous
Barika
Biskra
Batna
Collo
El Marsa
Skikda
Annaba
Settara
Mila
El Harrouch
A.Ben Beida
Guelma
Constantine
Tamlouka
Bir.E.Arch
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Oum El Bouaghi
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III
IV
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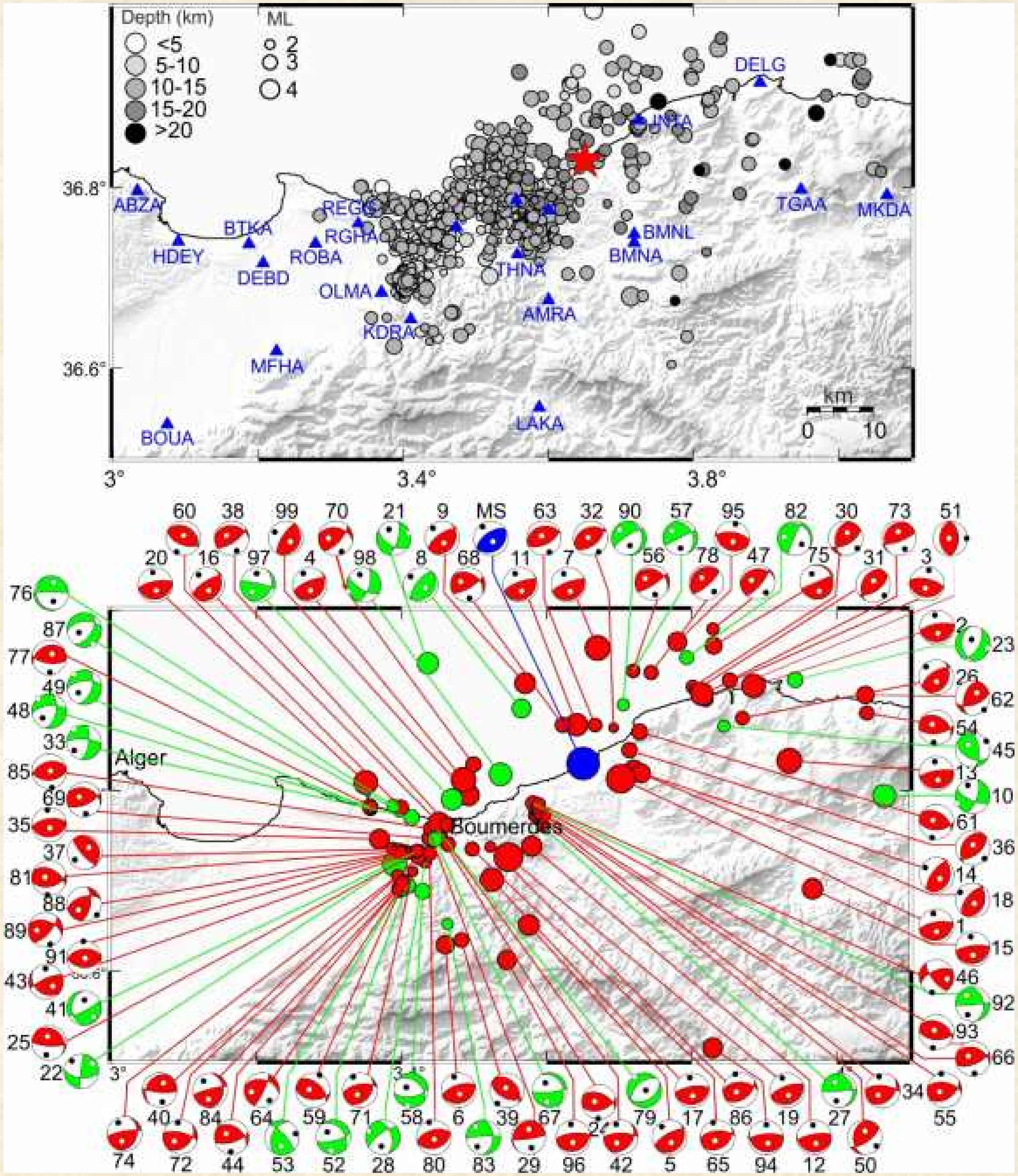
km
0
75
150



The aftershocks monitoring reveal the existence of active fault offshore Zemmouri. It shows also the migration of the seismicity towards the west triggering three other fault segments

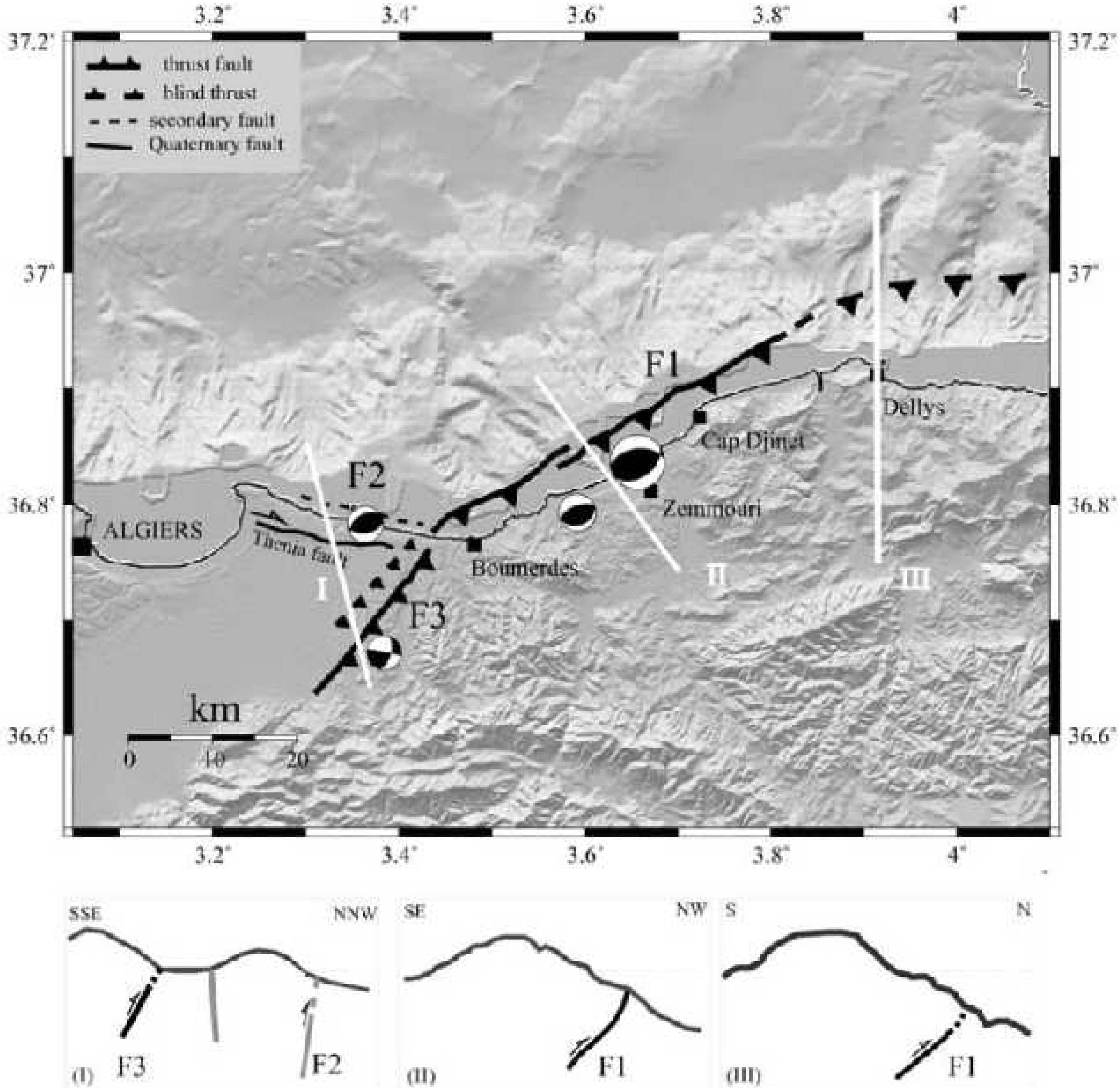
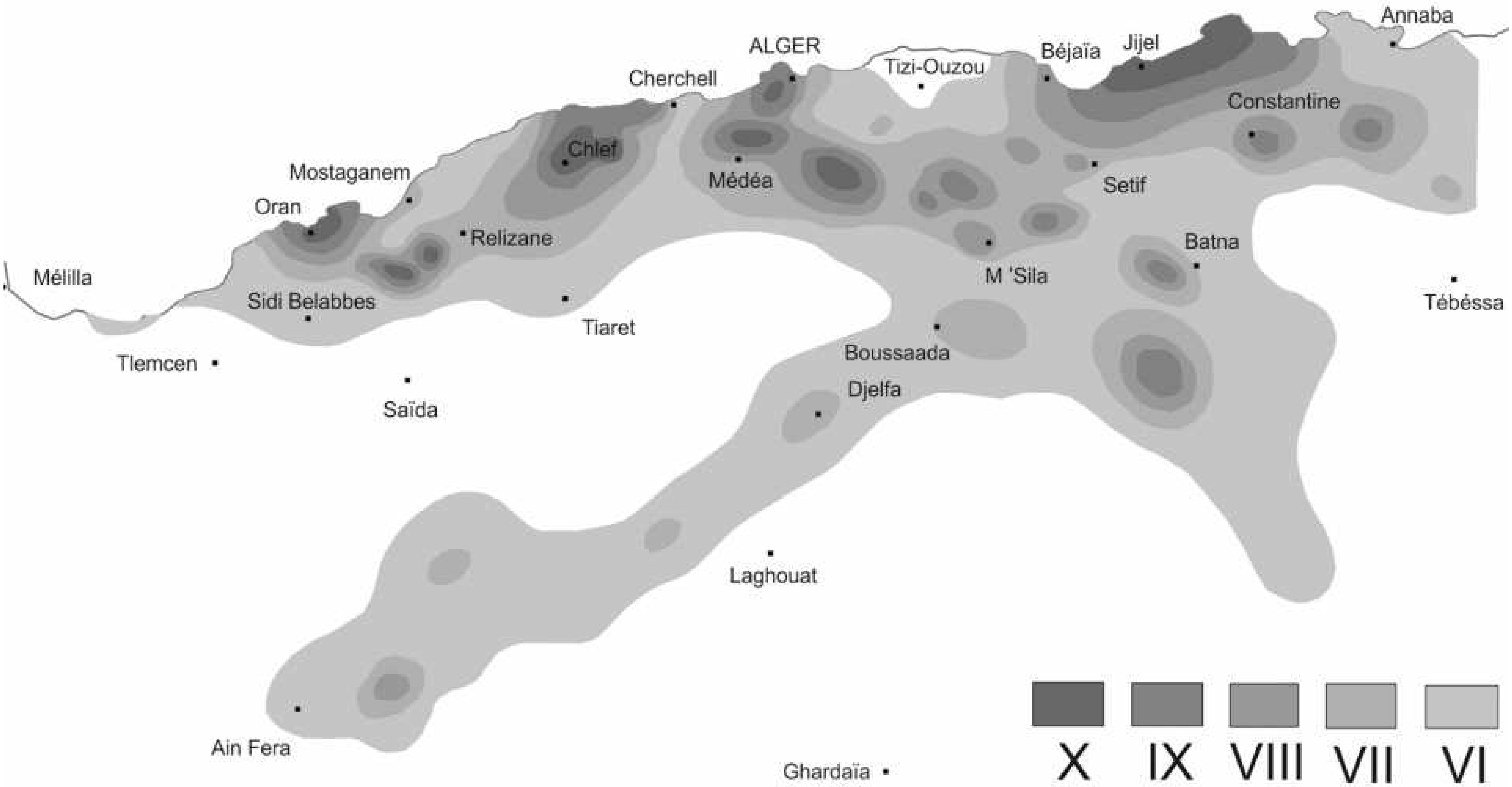


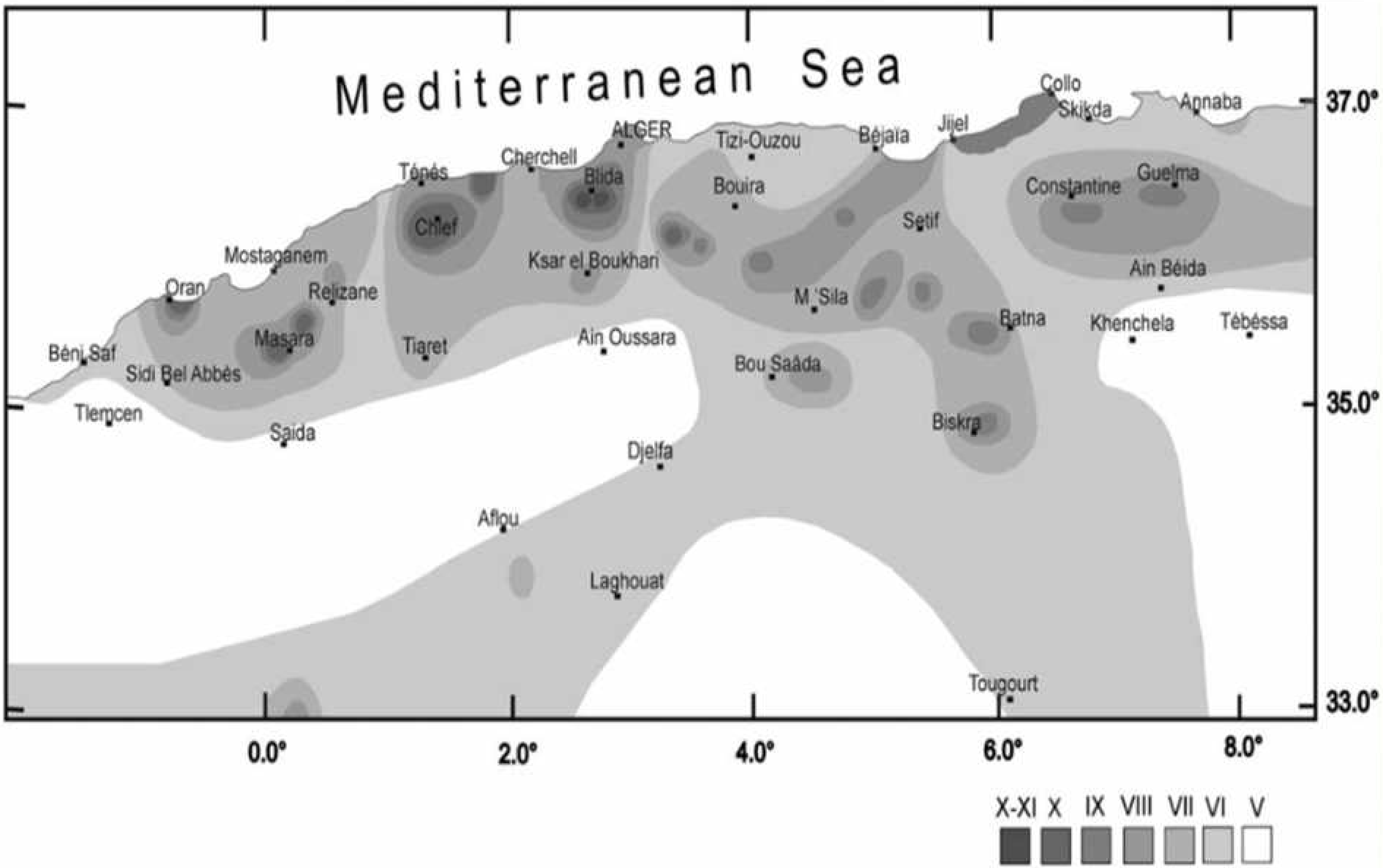
Figure 7. Tectonic model proposed for the 21 May 2003 earthquake rupture and related aftershocks sequence. F1, F2, F3 are represented on the schematic cross sections with their respective geometric and kinematic characteristics.

Fig. 2. Surface effects and damage in the epicentral area are shown. No surface faulting was visible inland. Photos: Upper left, coastal uplift (average 0.5 m) marked by the intertidal zone (white band); upper right, liquefaction features (sand blows); lower left, "pancake" building collapse; lower right, secondary surface cracks.

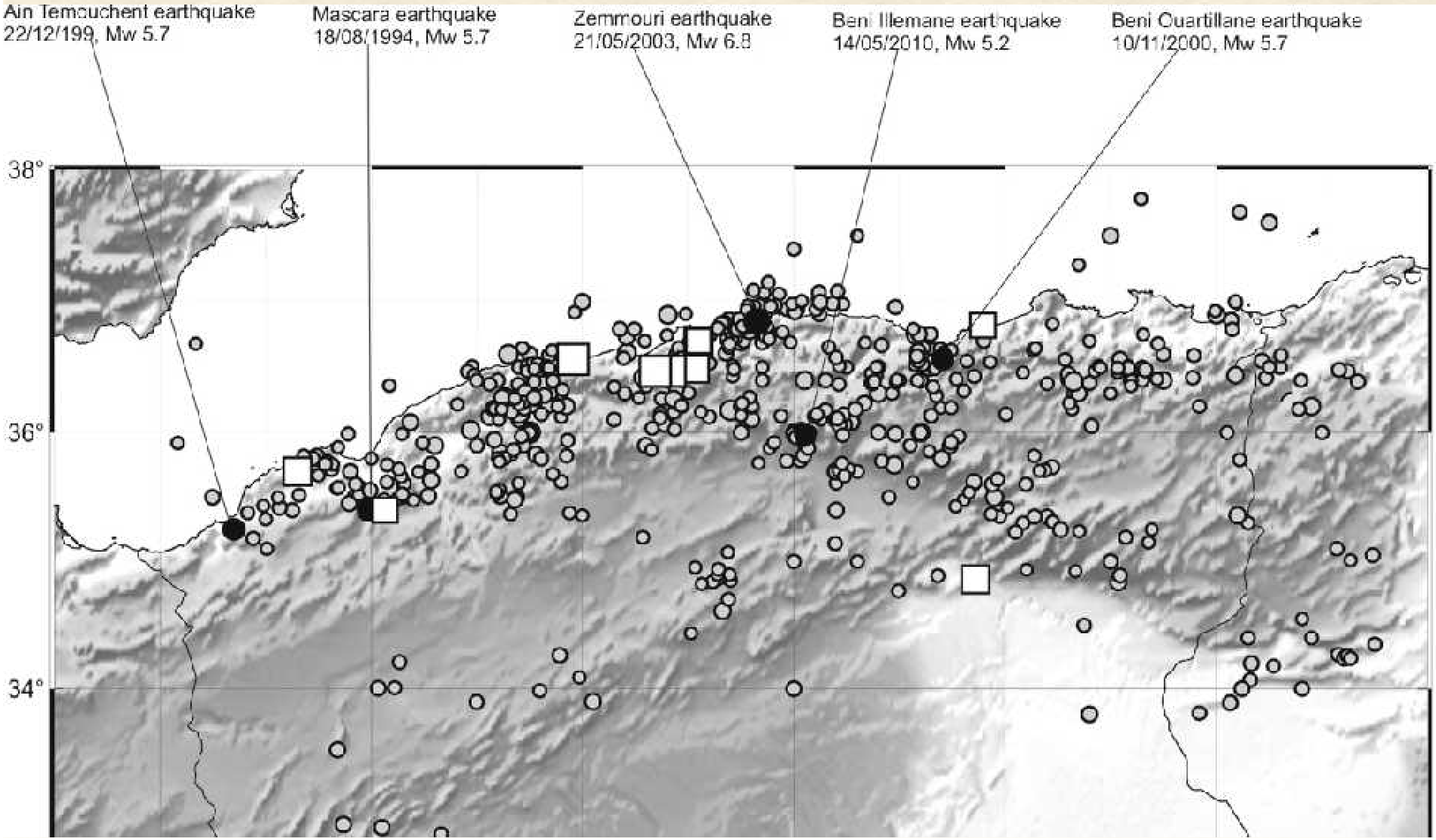
Maximum Observed Intensity Map by Roussel (1973)



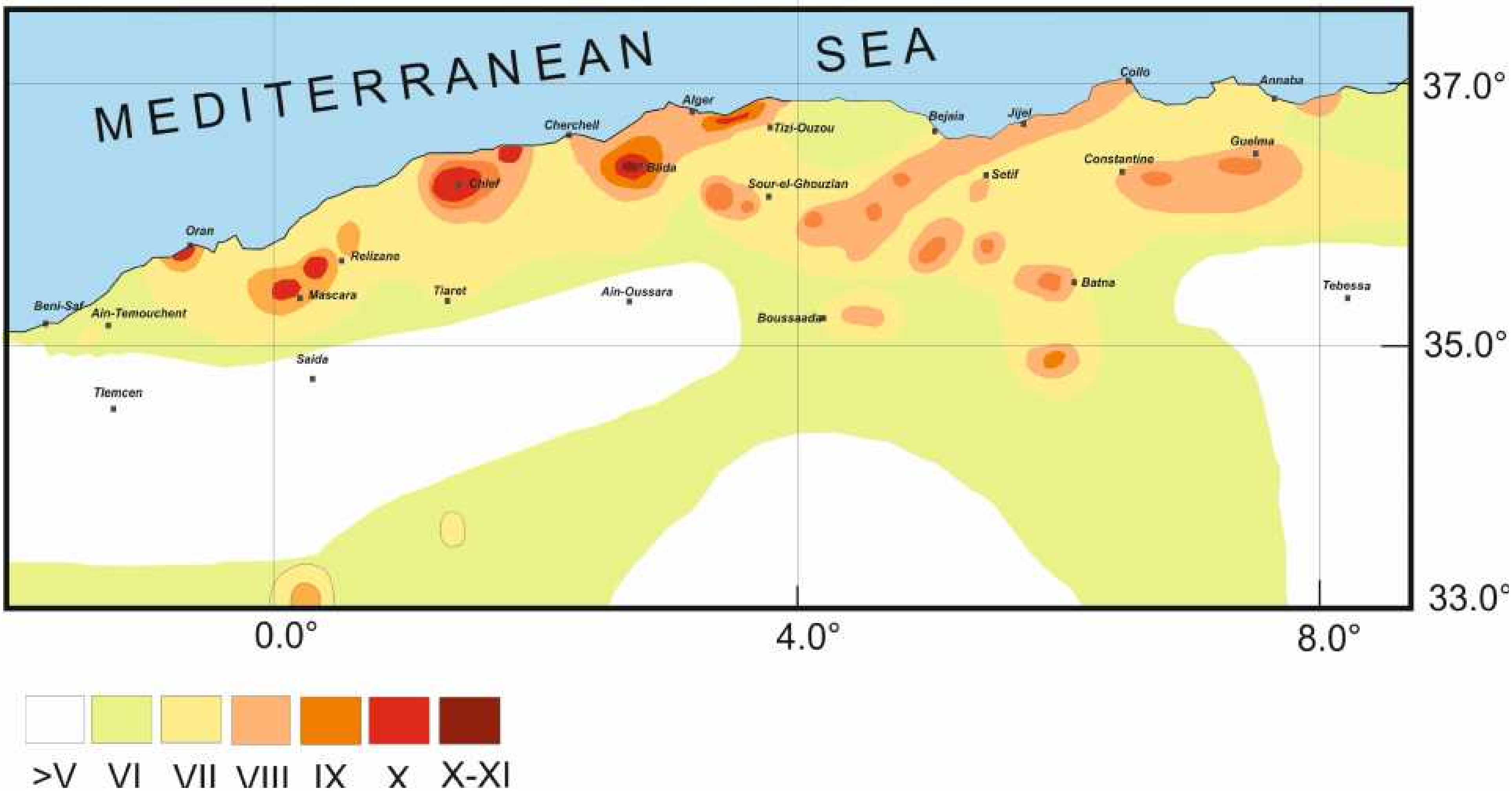
Maximum Observed Intensity Map (Bezzeghoud et al., 1996)



Recent Seismicity map for Algeria (2014)



Maximum Observed Intensity Map (MOI_{2014})
in Seismological Research Letters (Ayadi & Bezzeghoud, 2015)



HISTORICAL SEISMOLOGIST

Seismicity of Algeria from 1365 to 2013: Maximum Observed Intensity Map (MOI_{2014})

by A. Ayadi and M. Bezzeghoud

Online Material: Earthquake database.

INTRODUCTION

Algeria is one of the most seismically active areas in the Mediterranean basin. The available catalogs reported numerous destructive earthquakes striking different regions, such as Algiers (1365, maximum observed intensity I_o = X; 1716, I_o = X; Ambraseys and Vogt, 1988), Oran (1790, I_o = X; Lopez Marinas and Salord, 1990), Djidjelli (1856, I_o = IX; Ambraseys, 1982), Orléansville (1854, M_s 6.7; Rothé, 1950), El Asnam (1980, M_s 7.3; Yielding *et al.*, 1989), Constantine (1985, M_s 5.9; Ousadou *et al.*, 2013), Tipasa-Chenoua (1989, M_s 6.0; Bounif *et al.*, 2003), Mascara (1994, M_s 6.0; Ayadi *et al.*, 2002), and Zemmouri (2003, M_w 6.8; Harbi, Maouche, Ousadou, *et al.*, 2007; Ayadi *et al.*, 2008). This seismicity is related to the collision between the African and Eurasian plates and is located within the Tell Atlas of Algeria along the plate boundary zone. Two periods that are related to the installation of the Algerian seismic network are identified from the seismic catalog of Algeria: the pre-1910 and post-1910 periods.

Before 1900, numerous authors conducted seismic studies following the macroseismic approach, such as Perrey (1847), Chesneau (1892), and Montessus de Ballore (1892). All of these studies were based on human perception of shaking along with interpretations of intensity and descriptions of each earthquake's effects and damage. Isoseismal curves were drawn for each earthquake showing the extent of damage near the epicenter and the attenuation of the macroseismic intensity. The absence of instruments in Algeria before 1900 confined the seismological studies to their macroseismic aspect until 1910, which coincides with the implementation of the first seismological station in Algiers and began the instrumental era of seismological surveys in Algeria. Before 1910, all of the seismic events were studied by evaluating the intensity in relation to the damage produced and the effects generated by the event (Fig. 1).

This study considered only the maximum observed intensity (MOI) for each earthquake, which enabled us to draw a map of seismic zonation that highlights the regions of high, medium, and low levels of seismic shaking. Our map of MOI_{2014} represents a fundamental document for land use, especially for countries with available databases limited primarily to macroseismic intensity. This map is an updated version of the latest one from Bezzeghoud *et al.* (1996) and incorporates all the data available between 1365 and 2013, including the strong events of the last two decades, such as Mascara (1994), Ain Temouchent (1999), Zemmouri (2003), Laalam (2001), and Beni Ilmane (2010). More than a thousand intensity data points were used in this study; a portion of the data, available in the Algerian catalog, was historical, but most was recorded instrumentally. We have also reviewed all of the MOI maps that have been drawn, including those by an anonymous author (1925), Bezzeghoud *et al.* (1996), Bockel (unpublished document, 1970), Roussel (1973a,b).

SEISMICITY

The seismicity of Algeria (Fig. 2) is concentrated in the northern part of the country along the Tell Atlas (32° N–38° N, 2° W–9.5° E), which occupies the southern side of the Mediterranean basin and has been structured into folds and thrusts since the early Cenozoic by compression oriented in a north-northwest–south-southeast direction, with a shortening between the African and Eurasian plates of ~4 mm/yr (Bezzeghoud *et al.*, 2014). Over the last three decades, the region has experienced numerous destructive events that were linked to specific seismogenic zones such as the El Asnam, Mont Chenoua-Tipasa, and Zemmouri thrust faults and the Constantine strike-slip fault. Most of the seismic data are presented as intensities for the period of interest between 1365 and 2013. During this period, we considered events with maximum intensities greater than or equal to VI (Table 1) according to the database published by the Center for Research in Astronomy, Astrophysics and Geophysics (CRAAG, Algiers, Algeria) (Mokrane *et al.*, 1994), with the largest earthquakes occurring in Algiers (1365 and 1716, I_o = X) and Oran (1790, I_o = X).

The historical record of seismicity in Algeria is incomplete and is characterized by discontinuous coverage, especially for small- or moderate-sized earthquakes (Fig. 2). Thus, we have reported only well-documented events that have been revised by different sources (Rothé, 1950; Harbi, Benouar, and Benhallou, 2003; Harbi, Maouche, and Benhallou, 2003). Numerous small seismic events are obviously missing from the database for many reasons. However, we are confident that all of the major or damaging earthquakes within or near large urban areas have been mentioned in the catalogs used for this study. The seismicity map shows a sparse distribution that must

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Seismic database used in this work.

Electronic Supplement to

Seismicity of Algeria from 1365 to 2013: Maximum Observed Intensity Map (MOI_{2014}).

by A. Ayadi and M. Bezzeghoud

Table S1. Earthquake Database Used in the Preparation of the Maximum Observed Intensity (MOI_{2014}) Map

Date of Event (dd/mm /yyyy)	Time of Occurrence (hh:mm:ss)	Longitude (°)	Latitude (°)	Instrumental Magnitude	Observed Intensity (I_0)	Locality Where Event Was Strongly Felt	References[†]
02/01/1365	19:00:00	3.1	36.7	–	X	Algiers	Ambraseys and Vogt, 1988
10/03/1673	21:00:00	3.1	36.7	–	VIII	Algiers	SSIS
03/02/1716	02:00:00	3.1	36.7	–	IX	Algiers	SSIS
01/05/1716	--:--:--	3.1	36.7	–	VIII	Algiers	SSIS
01/01/1717	--:--:--	3.1	36.7	–	VIII	Algiers	SSIS
05/08/1717	23:30:00	3.1	36.7	–	VII	Algiers	SSIS
29/11/1722	--:--:--	3.1	36.7	–	VII	Algiers	SSIS
09/10/1790	01:15:00	−0.7	35.7	–	X	Oran	Rothé, 1950
--/03/1819	--:--:--	0.1	35.4	–	X	Mascara	Rothé, 1950
02/03/1825	07:00:00	2.8	36.4	–	X-XI	Mitidja	Rothé, 1950
27/09/1836	--:--:--	−0.6	35.7	–	VI	Oran	SSIS
04/12/1842	03:00:00	3.1	36.7	–	VIII	Mitidja	SSIS
18/06/1847	05:40:00	2.9	36.7	–	VII	Mitidja	Rothé, 1950
09/02/1850	--:--:--	4.8	36.3	–	VIII-IX	Guenzet	Hée, 1950; Rothé, 1950; Mokrane *et al.*, 1994; Harbi, Benouar, and Benhallou, 2003; Harbi, Maouche, and Benhallou, 2003
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Héliopolis	Rothé, 1950; Harbi, Benouar, and Benhallou, …

- Thank you for your attention