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Occurrence and impact of characteristic earthquakes in northern Algeria

By

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Outlines

- ❑ **Introduction**
  - -An extreme event
  - -A characteristic earthquake
- ❑ **Seismotectonic setting of the studied area**
- ❑ **Examples of characteristic earthquakes**
  - -The case of El-Asnam 1980 (Ms=7.3) earthquake
  - -The case of Zemmouri 2003 (Mw=6.8) earthquake
- ❑ **Summary**

Extreme event

❑An extreme event is a phenomena that is at the extreme of the historical distribution

❑ An extreme event is characterized by:
- The probability of occurrence (long return period in terms of hundreds of years)
-The affected area (widespread consequences).

❑Types of events:
- Normal event (very frequent and often moderate)
- Major event (strong and frequent)
- Extreme event (very strong and infrequent)

Characteristic earthquake

- The term characteristic earthquake was proposed by Youg & Coppersmith in 1985.

- A characteristic earthquake is the maximum earthquake that a given specific fault could produce.

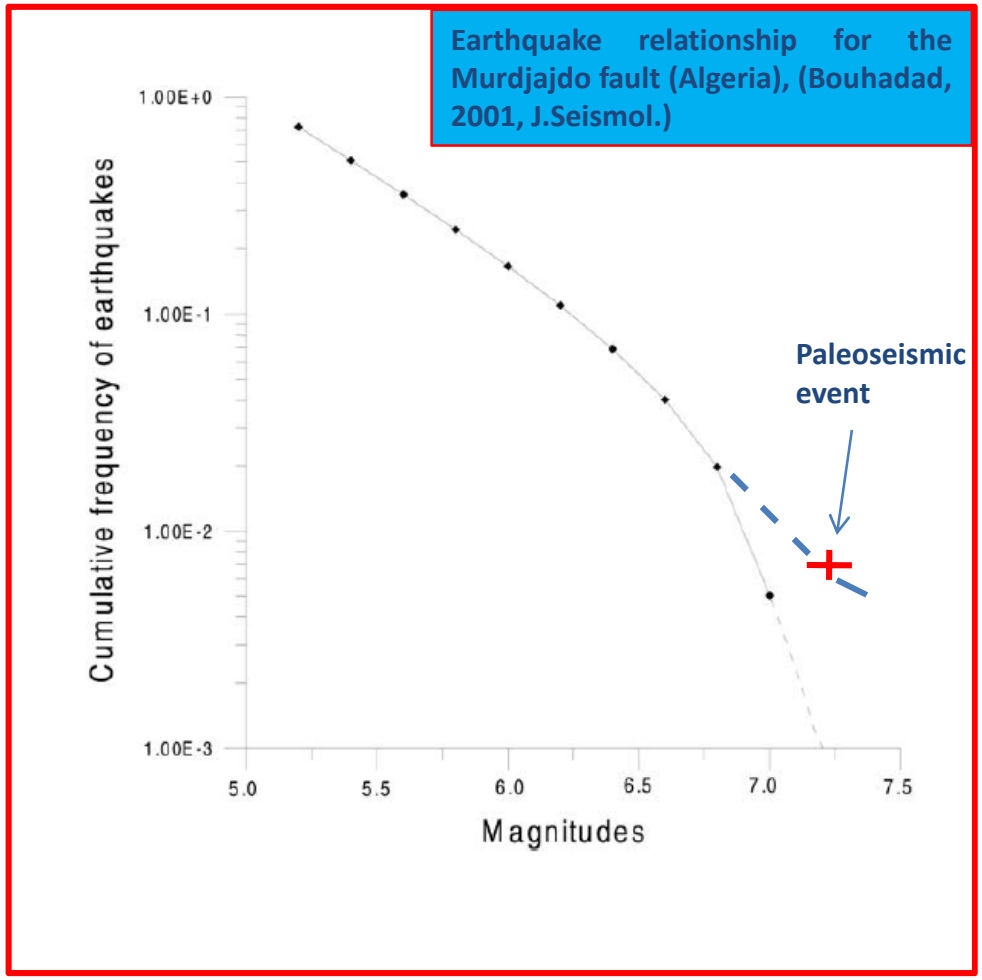
- It implies that the total length of the fault is involved in the rupture (involvement of all segments of the fault).

- World data show that the maximum rupture length during a characteristic earthquake is about 75% of the total length of the fault (Bonilla et al., 1984.BSSA). For instance during the El-Asnam (Algeria) Ms =7.3 (1980) earthquake 36 km of the 48km of the length ruptured (Bouhadad, 2001).

- Characteristic earthquake are characterized by long return periods (many hundreds or thousand of years) (500 years in the case of El-Asnam earthquake (Meghraoui & Doumaz, 1996, JGR)

- Characteristic earthquakes occur more frequently than could be predicted by statistical models (Young and coppersmith, 1985, BSSA)

- Characteristic earthquakes are defined from paleoseismology observations. (consideration of characteristic earthquakes has direct implications for the reliability of seismic hazard studies).


Earthquake relationship for the Murdjajdo fault (Algeria), (Bouhadad, 2001, J.Seismol.)
Cumulative frequency of earthquakes
1.00E+0
1.00E-1
1.00E-2
1.00E-3
5.0
5.5
6.0
6.5
7.0
7.5
Magnitudes
Paleoseismic event

Segmentation of faults

- A specific active fault may produce moderate, strong or characteristic earthquakes because of it's segmentation. Segmented faults present various morphologies:

- Curved faults (Case of El Asnam fault).

- Fault en zig-zag (branched segments of different trends/ relayed segments)

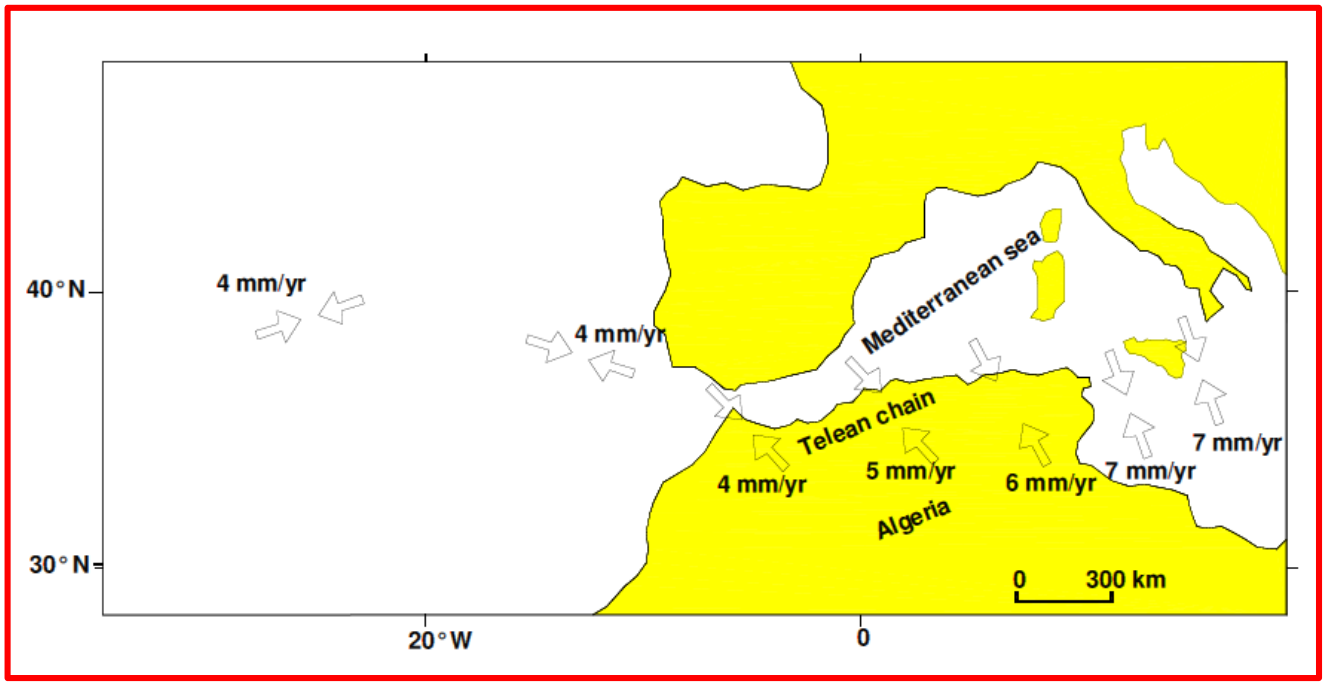
- Faults with an- echelon disposition

- Presence of asperities

- Fragmented faults

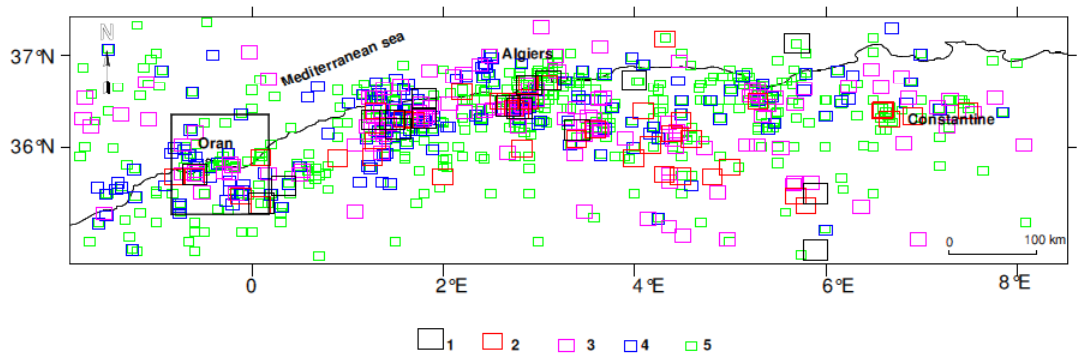
Seismotectonic setting(Novel 1 Model, DeMets et al. 1989):

- ❑Shortening rate in Algeria ranges from 4-6 mm/yr.
- ❑Stress direction is NW-SE.
- ❑Several active faults blind or not mainly trending NE-SW.
- ❑Active faults are located onshore and offshore.



Seismicity map of Algeria (1365-2011): Most destructive characteristic earthquakes in Algerian history are:

- ❑ Algiers 1365 (20 000 deaths)
- ❑ Oran 1790 (3000 deaths)
- ❑ Blida 1825 (8000 death)
- ❑ El-Asnam 1980 (3000 deaths)
- ❑ Zemmouri 2003 (2400 deaths)



: Seismicity of northern Algeria for the period 1365-2006. 1= M_s>6.0, 2= 6.0 ≥M_s ≥5.0, 3= 5.0 >M_s ≥4.0, 4= 4.0 >M_s ≥3.0, 5= M_s<3.0 (Benouar, 19984; CRAAG, 1994).

ZEMMOURI, May 21st, 2003 earthquake

- Mw=6.8, I_0=IX (MSK scale)
- Fault rupture: 2 segments about 50km
- Mean shoreline uplift: 0.5m
- Induced effects: Landslides and liquefaction
- Human lives: 2400 deaths, injured
- Affected construction 179 000
- Maximum acceleration: 0.58g at 40km far from the fault

Newly formed marine Terrace following shoreline uplift. Repetitive uplifts are also observed in the beach rocks (Meghraoui et al.2004, JRL).

Building collapse in the badly damaged area

Induced liquefaction during the zemmouri earthquake

2003 induced liquefaction

Evidence of paleoliquefaction in the same area (Bouhadad et al., 2009, J.of Seismol.)

EL-ASNAM , OCTOBER 10th, 1980 EARTHQUAKE

- Ms=7.3, I_0= IX (MSK scale)
- Fault rupture: 3 fault segments ruptured (36 km) (Characteristic event)
- Induced effects: Landslides and liquefaction
- Human lives: 3000 deaths, 8500 injured, Homeless: 4 00000
- Affected constructions : 60 000 housing units
- Flooded area by the obstruction of Oued Fodda river following the fault rupture. There has been evidence for repetitive flooding and river diversion in the past (Meghraoui & Doumaz, 1996, JGR) .

Summary

- Extreme events often strike surprisingly because of their infrequency .

- Northern Algeria is a prone area for large strong earthquake despite the relatively moderate rate of shortening between the African and Eurasian tectonic plates (4-6 mm/yr).

- Trace of strong past (Pre-historic) earthquakes (M>7.0) are often recorded by geological materials as paleo-liquefaction features, rivers diversions and shorelines uplifts. These materials constitute a precious tool for paleoseismic studies.

- About 80% of the population and facilities are located in the northern part of the country, where, the probability of occurrence of such exceptional events is higher, therefore, the probability that the hazard became disaster is higher.

- The need for an effective strategy to counter such a situation constitutes an urgency for geoscientists, land planners and authorities.