

The North African margin (Western Mediterranean Sea): Structure, evolution, and active deformation

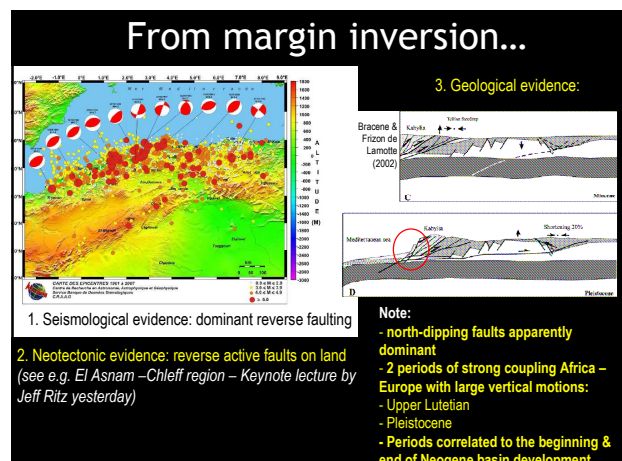
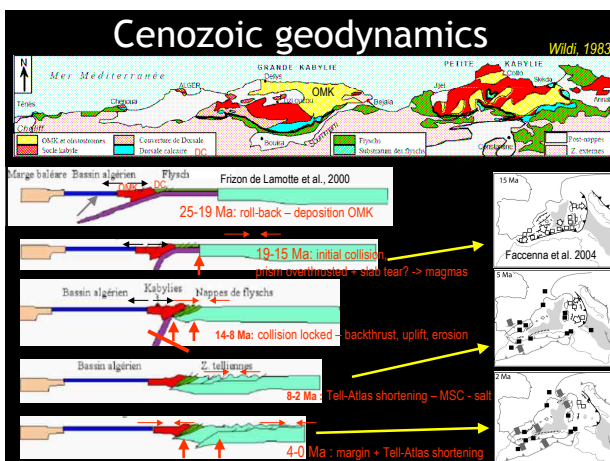
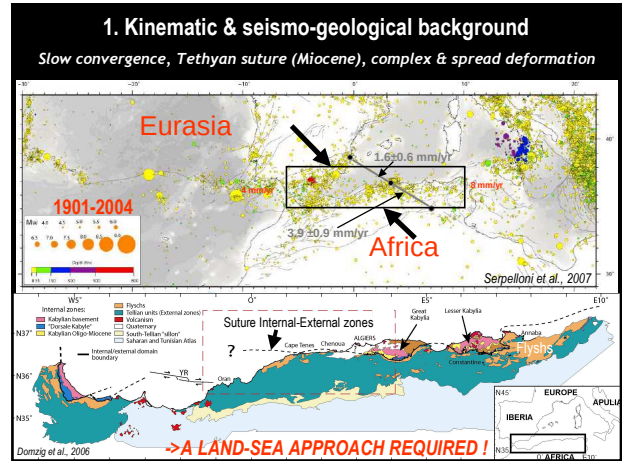
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on behalf of the Scientific teams of MARADJA (2003) & MARADJA2 (2005) cruises

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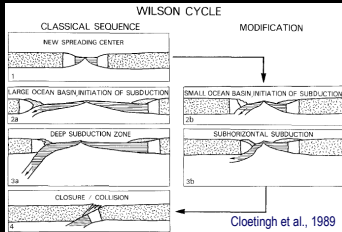
ESC 2010

-> Long term partnership
-> Complementary skills
-> French-Algerian cooperation
-> Multidisciplinary, integrative approach



... to subduction inception?

Numerous models, rare sites



2 scenarios of initiation of subduction

- Left: subduction of old oceanic lithosphere
- Right: lithosphere < 20 My -> early subduction (e.g. beside a marginal basin)

- > Age of the oceanic plate is not the dominant factor
- > If true in the Algerian case: implies subduction polarity reversal

Transition passive-active?

Elastic / frictional forces preclude subduction initiation, except if favoured by:

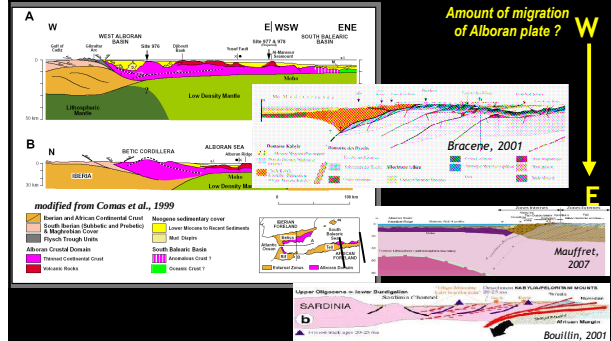
- Sediment loading
- Other factors:
 - ductile strength of the lower continental crust, sub-continental lithospheric mantle
 - density contrast continent-oceanic parts (Nikolaeva et al., 2010)
 - Structural and rheological heterogeneities, sharp transition COB, thick crust, boundary conditions (convergence)

(Bethoux et al., 2008)

Finite deformation

Available crustal-scale geological cross-sections:

- Incomplete
- Seldom
- Highly speculative because poorly constrained



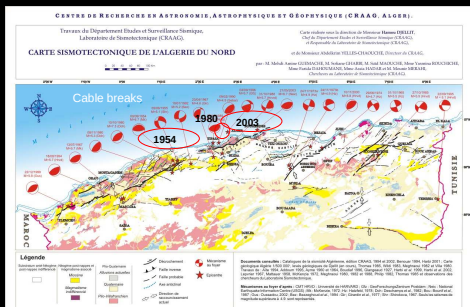
Earthquake-related deformation

Sea: Relationship large events – gravity flows?

- Offshore seismicity known since 3 centuries at least, but poorly estimated
- « Coastal » earthquakes (< 100 km from coastline):
 - Since 1950, 14 $M > 5$ events; 4 $M \geq 6$ events, among them:
 - 3 with tsunami and cable breaks: 1954, 1980, 2003
 - No detected turbidity current associated with the 1989 Chenoua event ($M \sim 6$)
 - 1700-1950: 5 events $I > IX$ ($6.5 < M < 7.5$); 3 with tsunami documented

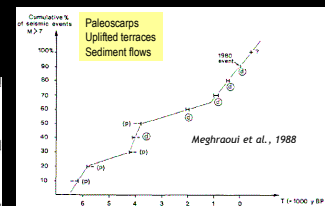
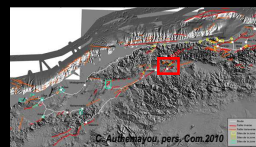
Cable breaks:

- Depend on:
 - earthquake PGA (magnitude and distance)
 - Power of turbidity currents: canyons + time elapsed between events!
 - Position and density of cables



Holocene Earthquake sequences : El Asnam Fault Zone

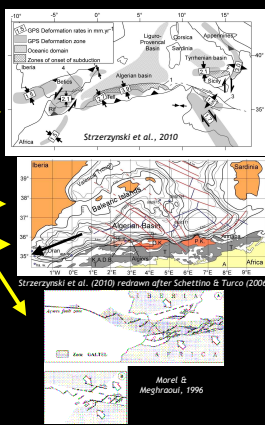
- 8 events $M > 7$ before 1980, over 6200 yrs
- 4 well established (d)
- 4 uncertain (p)



- > Repeated coseismic displacements
- > Minimum uplift rate : 0.6 mm/yr
- > $M > 7$ return period: 300-500 yr (« cluster » periods), 1000-1800 yr (« quiet » periods)

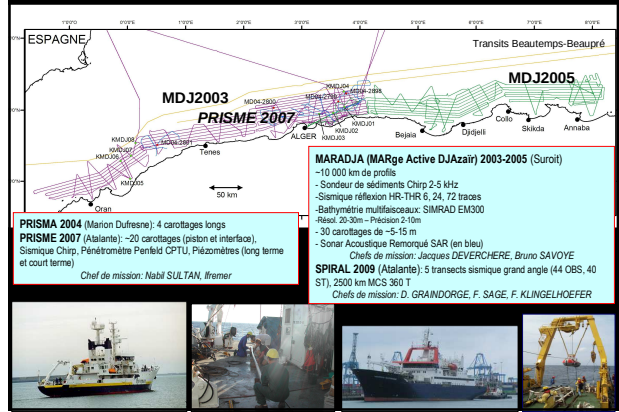
Main Issues

- **Reactivation** of the NA Margin? (Algerian passive & transform-type margins of Alboran Sea)
 - > **subduction initiation** ?
 - Slab break-off? Tearing?
 - Flexure, strain transfer, accretion?
 - Folds, faults, Messinian salt tectonics?
- Role of **structural & magmatic fabrics inherited** ?
- **Geodynamical & kinematic evolution** since 20 Ma ?
 - Offshore: Opening of the Algerian basin? motion of the Alboran block?
 - Onshore: « active thrust faults controlled by deep-seated dextral transcurrent faults » ? (Morel & Meghraoui, 1996)
- **Geohazards**:
 - Fault maturity and connections?
 - Recurrences, strain rates ?
 - Triggering of sedimentary instabilities ?

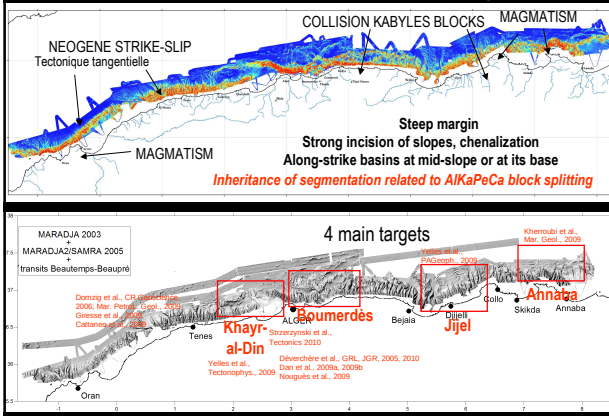


Outcomes: Geodynamics, style/strain rates, seismic hazards, recurrences

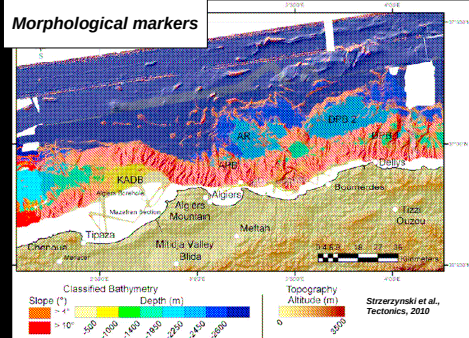
2. A High Resolution Marine Data Base

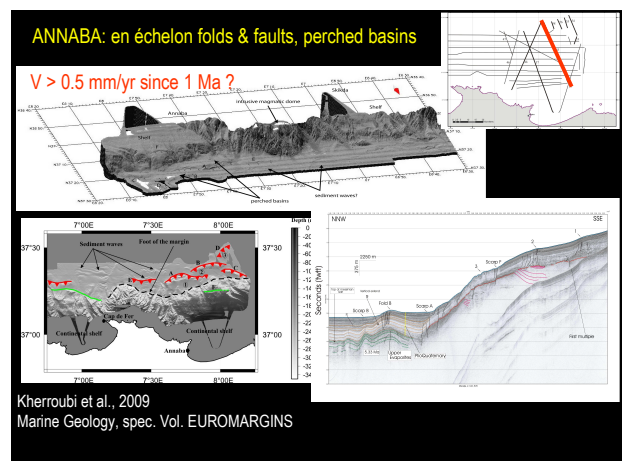
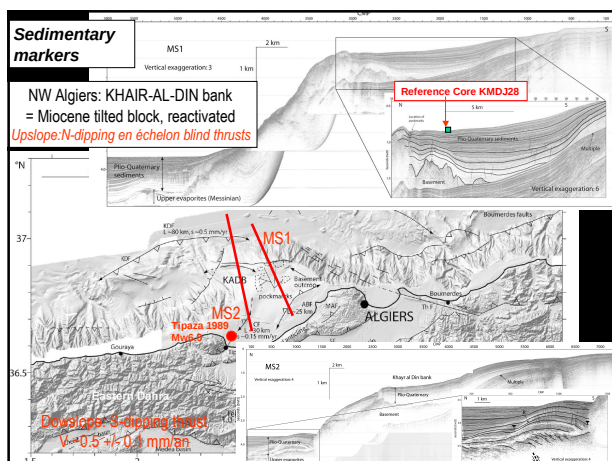
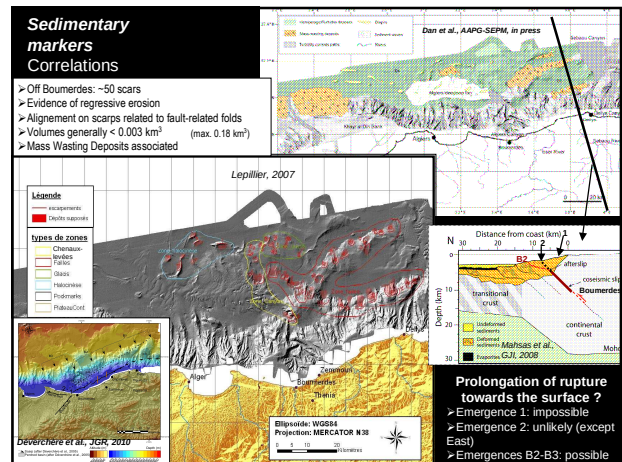
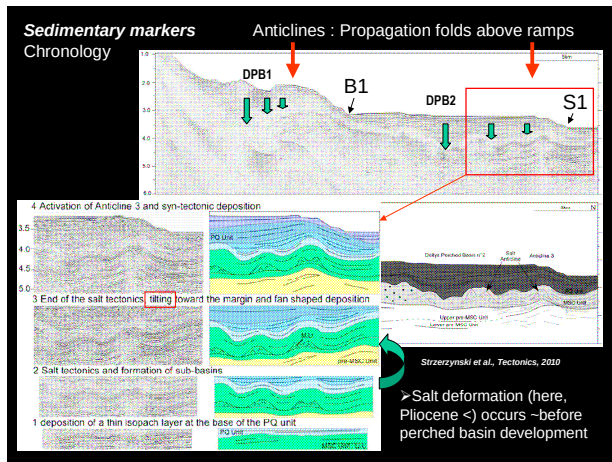


3. Morpho-structural overview of the margin



Finite and cumulative deformation: folds and faults





7. Preliminary conclusions & perspectives

Numerous witnesses of the ongoing tectonic deformation off Algeria

- **Margin structure:** complex, polyphased, shaped by several successive events:
 - N: (Oligo?)-Miocene rifting, Messinian Crisis, thick (flysch?) deposition, Quaternary folding & faulting, uplift (coastal rate of ~0.15 mm/yr, *see Authemayou et al. Poster*)
 - S: Collision with the African margin (suture)
- **Margin reactivation:** segments of fault-related folds, **S-dipping**, active since ~1.3 Ma, typical lengths 30-80 km, M 6.5-7.5, $V_{\text{dip}} < 0.5$ mm/an
 - Faults apparently distributed from coast to deep basin, major ones near foot slope
 - Interactions with salt & sedimentary dynamic distribution
 - Some inherited structures of the margin exert a control on recent strain distribution (suture, ~ oceanic ~ basement highs, but NOT Oligo-Miocene normal faults, or dextral strike-slip faults)*-> Early stages of plate limit reorganization (Polarity reversal) ?*
- **Seismic risk:** Time series from large turbidity flows? **Reachable objective**
 - Thin deposition, silty/sandy, ok for preservation of distal turbidites
 - > Large turbidity currents = result of sediment destabilisation induced by seismic activity*
 - Boumerdes: 8-10 turbidites on 10 000 yrs: *seldom, spaced earthquakes*
 - 2003, 1989, 1980, 1954 events: *Ruptures have effects on separated margin segments*
 - **Apparent threshold** $\geq M - 6$?

Perspectives

- Convert TWT- to depth profiles, image faults by HR tomography, identify the fossile slab *-> Project SPIRAL*
- Recover impacts of historical events : **1856 (Jijel), 1716, 1365 (Algiers),...**
- Correlate turbidites over neighbouring segments (**Tenes, KADB, Jijel, Annaba**)
- Estimate overlaps of turbidites & role of canyons on turbidite distribution
 - > Calibrate turbidites and source zones of future large events - intervals*
- Improve sea-land links: paleoseismology, marine/fluviat terraces (*see Authemayou et al. Poster*), sedimentary prism at the shelf break
- Model the ramp-flat evolution and interactions with salt/sediments

Recent publications (2009-2010)

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NOUGUES A., SULTAN N., CATTANEO A., DAN G., YELLES K., and PRISME team, Detailed analysis of a submarine landslide (SAR-27) in the deep basin offshore Algeria (Western Mediterranean), in: D. Moshier et al. (eds.), Submarine Mass Movements and Their Consequences - Advances in Natural and Technological Hazards Research, Springer, 28, 541-552, 2010.

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