Reply to comment by J. Déverchère et al. on “Zemmouri earthquake rupture zone (Mw 6.8, Algeria): Aftershocks sequence relocation and 3D velocity model”

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The occurrence of a large earthquake often offers the possibility to constrain fault geometry and related rupture characteristics (kinematics and slip distribution) and provides an opportunity to collect a wealth of seismological, geodetic, and tectonic data. The 2003 Zemmouri earthquake occurred along the eastern coastline of Algiers (Algeria) and enhanced our understanding of coastal and active tectonics in this section of the Africa-Eurasia plate boundary.

[2] Ayadi et al. [2008] present data from the 2003 earthquake sequence recorded within 2 months of the main shock. The aftershocks accurately relocated with a 3-D velocity model (tomoDD, Zhang and Thurber [2003]) extended NE–SW along a ~60 km rupture zone crossing the coastline. The epicenter locations do not extend 10 km offshore. The aftershock distribution includes events from 0 to 18 km depth though their density increases significantly between 5 and 13 km. The 40° to 50° SE dipping fault geometry is determined from a NW–SE section across the dense cluster of aftershocks located SW of the main shock (see sections B of Figure 3 of Ayadi et al.). These results are in agreement with the fault parameters of the main shock obtained from most published focal solutions (six of seven studies) and with the fault geometry and related slip distribution obtained from the inversion of InSAR and coastal uplift data [Belabbès et al., 2009]. Finally, Ayadi et al. [2008] provide an extensive discussion of their results compared with all papers published at that time. The schematic tectonic model proposed in the final analysis is simply based on the main shock parameters and aftershocks distribution, both indicating a SE dipping planar fault reaching the surface at a distance lower than 10 km from the shoreline. This approach is a common procedure widely used and tested in numerous earthquake studies with outcropping coseismic surface faulting, and has provided a good constraint on the fault geometry (see, e.g., Yeats et al. [1997] for a review).

[3] Section 2 of Déverchère et al. [2010] addresses the distance from the shoreline of the expected fault trace. The discussion is based on a misreading of our results. Ayadi et al. [2008] agree that the fault reaches the seafloor at a distance of 8–10 km from the coast: see paragraph 31 (“less than 10 km”) and Figure 3 III where zero corresponds to the Y = 0 line of the tomography grid, and not to the position of the shoreline. We confirm that Figure 3 III of Ayadi et al. is correct, including the topographic and bathymetric profiles and the aftershock locations. On the other hand, the faults were drawn free hand on Figure 7 of Ayadi et al., which presents an interpretative and schematic tectonic model deduced from our study, as underlined in the caption (there is no scale on the cross sections), and does not represent a direct and accurate observation. Last, we believe there is no reason to introduce in this discussion the locations of the largest aftershocks from Bounif et al. [2004], since these events occurred before we installed the temporary network and their positions were determined with data from only a few permanent stations using a simple 1-D velocity model (see error ellipses on Figure 2 of Ayadi et al.).

[4] Déverchère et al. rely in their comments on two new profiles and five papers, published after Ayadi et al. [2008], and two Ph.D. dissertations defended in Brest University. This approach allows us to reinforce our conclusions by using a Master of Science report recently defended [Aidi, 2008]: A French team from Geoscience Azur Laboratory (Sophia Antipolis University) installed five OBS stations offshore from 7 June to 26 June 2003. Only two OBS were recovered, which registered 191 events common to the in land temporary network. When integrating OBS picks into the data set, we observe a global ~1.5 km shift of the offshore epicenters toward the coast, leading to a narrowing of the epicenter cloud.

[5] Déverchère et al. present two echo sounder lines made offshore the epicentral area across the continental platform and claim the existence of undeformed sedimentary units. Unfortunately, they choose lines based on the schematic Figure 7 of Ayadi et al. instead of on the precise locations of
Figure 1. High-resolution echo sounder (Chirp 2–5 kHz) profile Mdj1-14 [Déverchère et al., 2010]. The lower profile delineates in color the deformed sedimentary layers at ~14300 (x axis). The blue and red layers indicate a clear vertical offset.
bathymetry and aftershocks presented in Figure 3 III of Ayadi et al. and commented on in the text. This mistaken position of their profiles is clearly underlined by shallow water depth (150 m instead of ~1000 m) and the absence of scarps on the seafloor. It is compelling to note that with careful observation their lines clearly indicate disturbed layers, especially in Figure 2b of the comment of Déverchère et al. [2010]) at ~14300 (x axis) from which vertical offsets of the same levels can be inferred (see our interpretation, Figure 1).

Sections 3 and 4 of Déverchère et al. [2010] consist of assertions to support the flat ramp geometry model proposed by Déverchère et al. [2005]. Although this is an interesting point for debate, neither the aftershock distribution nor the coastal uplift data support this model. In conclusion, the comments do not offer any new evidence that leads preferential consideration of the flat-ramp geometry for the 2003 Zemmouri earthquake fault.

References

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