Hervé Philip: a summary of his contribution to Seismotectonics and Paleoseismology

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In this key note, I would like to pay tribute to the contribution of Hervé Philip's pioneering work to the field of seismotectonics and paleoseismology. I will also present and discuss some recent insights in active tectonics (e.g. earthquake recurrence intervals in intracontinental settings, slip rate variation along faults, or earthquake clustering).

Figure captions: Left: Hervé Philip, Professor University Montpellier 2, France
Right: International seismotectonics expedition in Mongolia (1990). From left to right: Amgalan Bayasgalan, Peter Molnar, Hervé Philip, Armando Cisternas, 2 drivers (Photo R. Kurushin).

Hervé Philip started his research career in Greece doing a PhD on the Aegean neotectonics (1974). Then, he extended his interest to the whole Mediterranean domain in the framework of a "these d'état" (1983) (see Philip 1997; Rebai et al. 1992). Meanwhile, he started a fruitful and original collaboration with seismologists from IPG Strasbourg (A. Cisternas and collaborators). The starting point of this collaboration was the magnitude 7.3 El Asnam earthquake of October 10, 1980 in Algeria, the most important event recorded so far in North Africa. The strength of Philip and collaborators' approach was to put together complementary disciplines such as structural geology, neotectonics, geodynamics and seismology and produce a comprehensive study of this large event in its tectonic environment (Ouyed et al., 1981; Philip and Meghraoui 1983; Meghraoui et al. 1986). Among other works on El Asman earthquake (see for instance Ambraseys AJEG 1981; King & Vita-Finzi Nature 1981; Yielding et al. EPSL 1981; Ruegg et al. BSSA 1982; etc.…), Philip et al.'s work highlighted the complexity of the rupture process (segmentation, multiple source mechanism, co-seismic folding) during a large seismic event. This work was also the opportunity for Herve Philip and M. Meghraoui to study paleoseismicity (Meghraoui et al., 1988), a new field of research that was developing in USA.

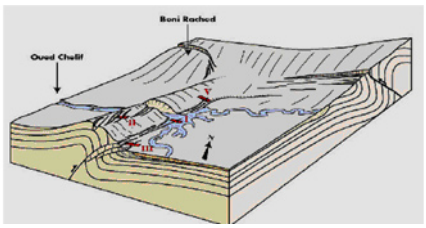


Figure captions: Left: The 1980 M7.3 El Asnam surface rupture in Algeria.
Right: 3D diagram sketching the structures involved in the El Asnam earthquake: The reverse faulting along the fault dammed the Oued Chelif. Above the fault, folding + left-lateral shear are attested by extrados right-stepping en-échelon fissures (red rectangles point out trench sites for paleoseismological investigations).

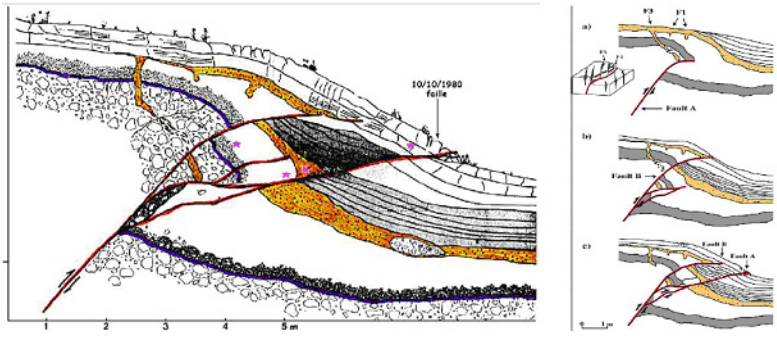
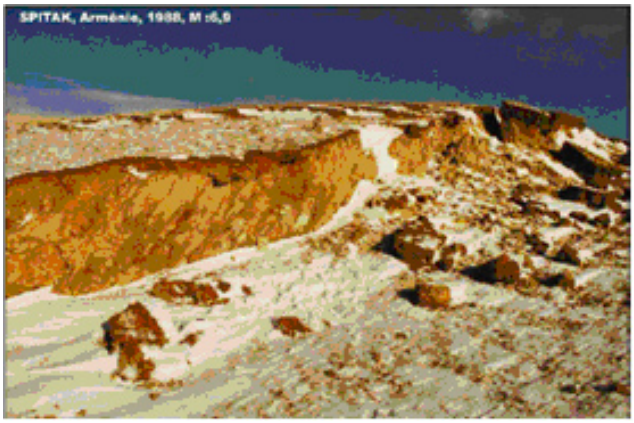


Figure captions Left: Sketch log of one of the trench opened across the El Asnam rupture, and interpretative scenario showing the occurrence of 2 pre-existing events before the 1980 earthquake.

The successful collaborative work between seismology and tectonics in Algeria was repeated in 1988 after the M6.9, December 7 Spitak earthquake in Armenia (Cisternas et al. 1989; Philip et al. 1989; Philip et al., 1992). The Spitak earthquake was the first well-documented event directly associated with surface breaks in the Caucasus region. As for the El Asnam event, the complementarities of observations from tectonics (e.g. detailed map of co-seismic displacements at surface) and seismology (focal mechanisms, aftershocks and strong motions analysis) pointed out the complexity of the rupture pattern both in surface and at depth. Philip and collaborators' detailed work of this intra-continental event provided an outstanding kinematic model of the fault zone that had generated the earthquake.



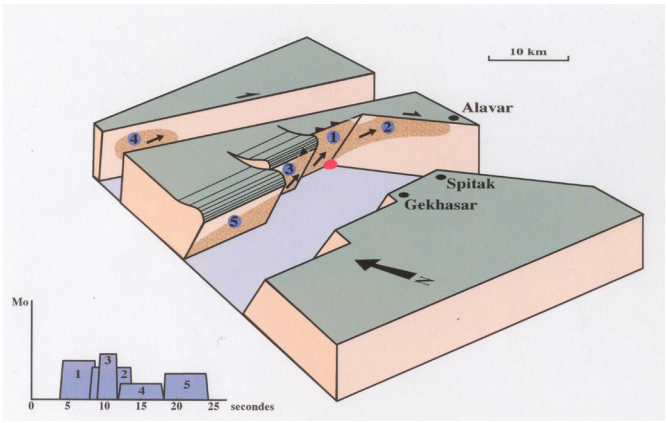


Figure captions: Left: The 1988 M6.9 Spitak surface rupture in Armenia..
Right: 3D diagram sketching the five faults segments involved during the Spitak earthquake and their rupture chronology (bottom left).

The Spitak event was also the opportunity for Hervé Philip to develop his investigations in the field of paleoseismology. The trenches across the Spitak fault revealed the occurrence of one earlier event comparable to the Spitak earthquakes during the past 17000 years, characterizing a slow moving intracontinental trust fault.
With the 1988 Spitak earthquake study, and a few years later, the 1991 Racha Dzhava earthquake in Georgia, new fields of investigations opened in collaboration with scientists from Armenia (Karakanian, Avagyan and collaborators), Russia (Borisov, Rogozhin, Kurushin, and collaborators), Mongolia (Baljyniamm, Bayasgalan and collaborators) and USA (Molnar and collaborators). Starting in the early 90's, these investigations in Mongolia and Armenia aimed to characterize the activity of large intracontinental strike-slip faults capable of producing strong earthquakes (M>7), by estimating their slip rate and the recurrence intervals of past seismic events (e.g. Baljynniam et al., 1993; Ritz et al. 1995; Philip et al., 2001). These works are presently continuing with new issues as for instance characterizing and understanding slip rate variations along faults or earthquake clustering.

Left: The 1905 M8.5 Bolnay earthquake surface rupture in Mongolia
Center: The 1957 M8 Gobi-Altay earthquake surface rupture in Mongolia
Right: H. Philip and A. Avagyan loging a trench opened across the Sunnik fault in Armenia.

Hervé Philip and collaborators's studies brought important insights on numerous tectonically active regions (Algeria, Armenia, Chile, Georgia, Greece, Iran, Italy, Morocco, Mongolia, Peru, Turkey) where large earthquakes had occurred (Bolnay 1905, Gobi-Altay 1957, El Asnam 1980, Spitak 1988, Racha Dzhava 1991, Erzincan 1992; Antofagasta 1995; Izmit 1999).

Finally, one of the last contributions of Hervé Philip to earthquake geology was to transmit its extensive experience and knowledge to the young generation in the form of a text book that he wrote with J.C Bousquet and F. Masson (Philip et al., 2007). Following two outstanding books in the field of active tectonics and paleoseismology (Mc Calpin et al., 1996, Yeats et al., 1997), this text book is the first comprehensive French work in the field of seismotectonics and the seismic hazard.

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